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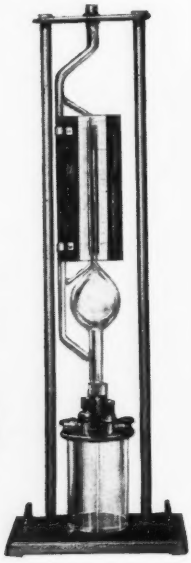

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EDUCATION IN THE NEW WORLD

THE report prepared by the Science Advisory Committee to the President of the United States is a significant document for all free-speaking peoples (see p. 87 of this issue)*. It presents the views of America's leading men of science and technologists and examines the ways in which American education can be strengthened so that it will more fully meet requirements in this age of science. The principles upon which the report is based and the recommendations stemming from them have immediate relevance to the state of education in Britain to-day.

No one in the United States would deny that the country should have a first-rate system of education. Yet, says the report, many American citizens do not realize that the strength, and even survival, of democratic society are determined primarily by the excellence and appropriateness of its educational patterns. Nor is everyone aware that learning, though beginning during the school years, is a life-long venture; that education is a part of life and not merely a preparation for it. Unfortunately this lack of awareness is as common in Britain as it appears to be in the United States and, even more unfortunately, applies as much to specialists in education as to members of the general public.

A second declaration of the Committee would find ready acceptance in all countries with a democratic system of government. A modern educational system, the Committee believes, should not only sharpen the intellectual capacities and curiosities of each new generation, should not only extract the essential core from ever-accumulating stores of knowledge, should not only find ways to produce new leaders equipped to add to these stores and to create all the new tools that the civilization requires; it must also produce citizens and leaders who will know how to use the knowledge and tools to advance social and cultural life.

Nor should discussions on education, as so frequently happens at educational conferences and meetings, be confined to buildings or budgets or even curricula. These, indeed, are necessary means to the end. We must think of the end itself; to introduce the growing child, the youth, and the adult to the best and most essential elements of the intellectual and cultural experience of previous generations; to do this in such a way that we stimulate curiosity and encourage each individual to look forward, not backward, to develop his own talents to their maximum, and to continue this development throughout his life.

The Committee also proclaims its faith in education as the most important of all social activities. "It is right and it is important that we should expend great effort and resources in order that every American child shall have the opportunity for the ten, the fifteen, or even the twenty years of formal educational experience required to give him full command of his intellectual powers and enable him to live a rich and fruitful life, both as an individual and as a citizen".

These are the fundamentals of education in a democracy and need frequent examination to determine how far practice falls short of precept. In Britain they should form a useful corrective to the ever-present danger of complacency which bedevils educationists at local- and government-level, who, too often, use advances on limited fronts to obscure the lack of progress over the educational field as a whole.

The Committee's statement stands out chiefly for the importance it attaches to intellectual excellence, to the need for stretching students to the utmost of their capabilities, to enhancing the prestige of the teacher and to improving the standards of scientific education both for the specialist and the non-specialist; above all, and as the report makes very clear, for the recognition that the strengthening of science and engineering education requires the strengthening of all education.

The need for much greater emphasis on the gifted—though not at the expense of the less gifted—has considerable significance for Britain to-day. The President's Committee recommends that opportunities should be provided to draw out both gifted and less gifted to the limit of their intellectual and emotional capacities. Unfortunately, education cannot be considered outside the framework of the society for which it is intended and, in Britain, two opposing views have grown up. One, broadly represented as egalitarian, is pursuing policies which tend to reduce the facilities and challenge for more intellectual children by emphasizing that there must be equal opportunities available for all. In their quite natural desire to look after the weaker brethren it frequently means that the less gifted are given relatively greater attention and facilities than those with greater mental endowments. The other view, sometimes described as the superior, seeks, under the guise of character-training, to perpetuate a system in which mere attendance at a well-known school is thought to be more than adequate to make up for deficiencies in intellectual abilities.

The importance of character-training is continually being stressed in the British educational system, and much school work is attuned to this; the achievements are admired by the whole civilized world. Not enough recognition is given to the fact that it is the brain which wins the break-through to new knowledge; the child gifted with high intelligence should always be sought for and given opportunities to expand his intellectual capacities to the utmost. An 'egg-head' deserves wide admiration as a national asset, and should not be treated with mild amusement as a harmless eccentric.

* "Education for the Age of Science" (The White House, Washington, D.C., May 1959).

If Britain is to survive in a world where educational systems will become increasingly scientific and technological, much more attention to the gifted child must be given both by those who proclaim equality and by the trainers of character. Grammar schools, with their proved records of success, must not be lightly abandoned in favour of experimental comprehensive schools simply to satisfy political aspirations and clamour. The major public schools, with their proved records of success, could provide a very much greater service to the nation if entry to them were governed by intellectual and emotional capacity rather than by the parents' ability to pay. Unless they are prepared to change in the interests of the whole nation, existing methods of entry to these schools may well lead to their own undoing.

Nor can the gifted child be developed where its early days are spent as a member of a class of forty or so children in a primary school. Here the aspirations of the Ministry of Education and of the teaching profession are remarkably low in that the provision of classes of thirty at all levels would seem to usher in the millenium. The difference between the quality of boarding school education and day school education may not be so much due to the residential factor as is commonly supposed. Much more important may be the fact that education in the public schools is organized on a much more individual basis, whereas the State system of education still savours of mass production. One of the strengths of the grammar schools has been the individual attention paid to scholars in sixth forms. With the development of much bigger sixth forms in comprehensive schools, junior colleges and bigger grammar schools, there is the danger that State schools may decline in quality compared with the public schools, where classes of thirty would often be regarded as three times too many.

In his introductory comments to the Committee's report, President Eisenhower writes that one subject warrants special emphasis—"the importance of raising the standing of our teachers in their communities. Higher salaries are a first requirement, but we need also to recognize the great importance of what teachers do and to accord them the encouragement, understanding and recognition which will help to make the teaching profession attractive to increasing numbers of first-rate people". The President's belief and wish would find many echoes in Britain as well as a re-echo about whether or not the teaching profession goes the right way to deserve greater prestige. The growth of pressure groups inside the profession, the emergence of trade union organization and of threats to strike, and the annual conferences at which the only topics discussed are pay and conditions have all helped to build up a public opinion which does not always see the teacher as a man dedicated to his calling. If the teacher is to enjoy greater status he must first of all prove worthy of it. This is unlikely to occur so long as the dominant voice comes from teachers who have been trained for only two years and who make up the large majority of the profession.

Practical means by which the status and quality of the teaching profession could be improved are described in the report and could well be copied in Britain. A closer and continuing link with universities and research institutions, the provision of more refresher courses at which leading men of science and technology keep teachers up to date with new knowledge and discoveries, collaboration between outstanding scientists and teachers in the design of new curricula to give pupils an "introduction to those areas of science and technology essential to an understanding of the problems of a modern society", the scholar's guidance and help in the provision of new text-books of science and technology at all levels, an adequate supply of films, television programmes, slides and tape-recordings to help the teacher in his work—these and other ways should and will increasingly have to be used if the teacher is to remain reasonably up to date in a rapidly changing age of science. There is little use in changing curricula unless the teachers have the new knowledge and are competent to teach it.

To help the teacher to remain aware of developments in technology, contacts with industry should be much closer than they are to-day. This will not only help him to keep abreast of advances in technology, but will also enable him better to understand the industrial life which the majority of his pupils adopt on leaving school.

The need to broaden the outlook of the specialist in science by giving him an introduction to other departments of science and technology has been well recognized in Britain by university extra-mural departments. The latter have also done valuable pioneering work in enabling the non-specialist to grasp the wider implications of science in society. Their efforts have been much curtailed by restrictive financial policies ; the reports of extra-mural departments at Oxford, Nottingham and other universities for 1958 should be read in conjunction with the call to action set out in the report of the President's Committee.

How much more could have been done has already been shown by those area committees of the British Association for the Advancement of Science which are not only taking outstanding lecturers to large and enthusiastic audiences from women's institutes, etc., but are also answering the long-expressed wish of provincial cities like Liverpool, Nottingham and Sheffield for their own "Royal Institution Christmas lectures". The British Association area committees should now see that any special lectures arranged should not only be available for school-children but also for apprentices, whose formal education is far from complete ; receptive and ready-made audiences will also be found in various foremen's and managers' groups inside factories themselves.

The Committee's report directs attention to the lack of science teaching in the liberal arts colleges of the United States. While in Britain there is no close parallel to these colleges, it is surprising that, even in 1959, the many theological colleges pay little or no attention to the teaching of science. It is difficult

to believe that some of the time spent on dogma might not more profitably be spent in making prospective parsons familiar with the broad paths of science; courses in social anthropology might be of practical concern to future missionaries.

That the strengthening of science and engineering education cannot be undertaken except by strengthening the country's general educational system is a point well made by the Committee and underlined by the President himself. In Britain the direction is right, but it may well be considered whether the pace is rapid enough. There are still too many black-listed schools. Hopelessly overcrowded classes in primary schools present teachers with problems in which education is replaced by mass instruction. The high hopes held out for secondary modern schools have not been fulfilled. County colleges remain a dream, and, because of the shortage and quality of staff at many technical institutions, the facilities available for many day-release students often account for appalling wastages between the first and last years of City and Guilds and National Certificate courses. Shortages of competent lecturers in mathematics and science at teachers' training colleges have led to a vicious circle which results in the bad teaching of mathematics and science in many junior schools. The lack of hostels for students in senior technical colleges and universities and consequent living in overcrowded lodgings makes many university lives narrow and drab.

These are some of the features of the British educational system which should be examined when too much is made of our advances. The report of the President's Advisory Committee should have both a stimulating and salutary effect in Great Britain, in the United States and in the whole Western world.

EXTREMELY HIGH TEMPERATURES

Conference on Extremely High Temperatures

Boston, Massachusetts, March 18–19, 1958. Edited by Dr. Heinz Fischer and Lawrence C. Mansur. (Sponsored by Electronics Research Directorate, Air Force Cambridge Research Center.) Pp. xi+258. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 78*s*. net.

THIS volume is an account of the first conference on extremely high temperatures sponsored by the U.S. Air Force Cambridge Research Center, under the chairmanship of Dr. Heinz Fischer. At first sight it looks as though the U.S. Air Force were in competition with the Atomic Energy Commission in supporting thermonuclear research at a time when those activities of the Commission called "Project Sherwood" were all classified, and there are clear indications that investigators under the Air Force contract are covering some of the ground the Atomic Energy Commission's scientists had covered long before. But the conference was based on a broader realm of science than thermonuclear research; it embraced the study of high-current arcs and materials capable of withstanding extremely high temperatures, with the result that all subjects were treated rather sketchily and a specialist reader is likely to be interested in only one or two papers in the volume.

Several papers deal with the development of very high speeds of small pockets of gas driven by shock waves, work not unlike the large quantity of work reported by Post and others from Livermore. Janes and Patrick accelerated an annulus of gas between cylinders to 3×10^7 cm./sec. with currents rising at 10^6 amp./μsec., and Bostick describes the propulsion of a small volume of plasma at 2×10^7 cm./sec. ejected from a deuterium-loaded titanium gun, while Nadig and Bohn give a preliminary account of the shooting of a plasma of exploded wire between long copper plates.

Several papers deal with the study of high-powered arcs at atmospheric and higher pressures, arcs dissipating 1,000 kW. of d.c. power, stabilized by a water sheath such as was originally developed at Kiel. The plasma of gas emerges from the arc chamber at temperatures up to 15,000 degrees and is constricted to some extent by the electrical pinch-effect. Ghai mentions that the most serious limitation to the application of these very high-intensity plasmas has been the erosion of electrodes, and states that in the past year such erosion has been reduced a hundredfold, but unfortunately he does not state how this has been achieved. Bonin and Price, on the other hand, present informative figures on the ablation and erosion of different materials—which might be used in rocket cones—when subjected to the plasmas from these arcs.

A session on temperature measurement produced some valuable papers. Drummond outlined the microwave properties of high-temperature plasmas and showed that it should be possible to record with microwaves temperatures leading up to fusion. Pearce presented valuable calculations about the density of light-emitters deduced from the observed brightness across the diameter of a cylindrical light source, and two papers deal with the deduction of arc temperatures from the hydrogen-line broadening.

There are several brief papers on energy storage, capacitative and inductive, and one by Finkelstein outlines the application of a 100,000-joule bank of condensers having specially low inductance (one millimicrohenry total) to develop a betatron field of up to 200,000 gauss over an orbit of 5 cm. radius, to achieve the particle acceleration needed to disintegrate matter not into the 'fourth state', namely, electrons and protons, but into the 'fifth state', namely, nucleons and mesons. In this connexion Levine *et al.* review the problems encountered in generating magnetic fields up to 750,000 gauss for milliseconds. The article on the feasibility of thermonuclear propulsion sounds like science fiction and my reaction was "first catch your hare".

T. E. ALLIBONE

ELECTRON TECHNOLOGY

Electron Physics and Technology

By Dr. J. Thomson and E. B. Callick. (Physical Science Texts.) Pp. xiv+527. (London: English Universities Press, Ltd., 1959.) 50*s*. net.

THE publishers say that this work is intended to provide a sound theoretical basis for the student who is pursuing an honours degree in either physics or electrical engineering. In fact, the authors seem to have cantered lightly over the fields of electron physics and elementary valve circuits, skirting around

difficulties, and reserved their energies for the technology. The physicist may be assumed to learn his electron-physics elsewhere, but is it fair to the engineer to show him on p. 20 a graph from which the most probable energy of a (conduction) electron in a metal is seen to be about 2eV. at room temperature, but then to tell him on p. 84 that the most probable electronic energy in a metallic conductor is kT ? Again, on p. 111 it is stated that a class B push-pull amplifier is biased to zero standing current. Does not the student deserve a more realistic treatment, even if that requires some further explanation of the actual shape of a valve characteristic ?

Sections 4, 5 and 6, on microwave devices, special-purpose tubes, and materials and construction, are at a much higher standard, and it is perhaps significant that most of the chapters in these parts give some reference to other published work, while the earlier chapters do not. The chapter on switching and scaling tubes is particularly valuable.

As must always happen in a rapidly developing subject, history has overtaken the authors. They have covered travelling-wave tubes up to the stage of using a velocity-jump to reduce beam noise, and they have a chapter on transistors ; but they do not deal with the maser, which involves concepts of sufficient importance to be studied by anyone interested in the fundamentals from which the future of electron technology will spring. The general impression is that this book is good on electron technology but does not deal with principles as well as one is led to expect from a book which claims to cover physics as well as technology.

D. A. Bell

PLANT MORPHOLOGY

Comparative Morphology of Vascular Plants

By Adriance S. Foster and Ernest M. Gifford, Jr. (Series of Books on Biology.) Pp. xi + 555. (San Francisco : W. H. Freeman and Company ; London ; Bailey Bros. and Swinfen, Ltd., 1959.) 9 dollars ; 76*s*. 6*d*.

THE aim of the authors of this very attractively produced text-book is, as stated in the preface, to give not only a purely factual description of the main groups of vascular plants but also to indicate the general principles and objectives of comparative morphology. They express the hope that the text will "in some measure orient and vitalize the teaching of plant morphology".

The general plan of the book is a little unusual. The first six chapters are described as "orientation chapters" and deal with the principles and problems of comparative morphology. Some of the topics briefly discussed are : the criteria used in phylogenetic interpretations, the stelar theory, alternation of generations, the telome theory, the phylogeny of sporangia and gametangia, embryogeny. A brief account of the aims and methods of experimental morphology is also given. Although this arrangement has some advantages, it seems probable that these general discussions would be more useful if they followed, rather than preceded, the descriptive chapters.

The main part of the book covers the whole of the so-called Tracheophyta. It deals in turn with the Psilopsida, Lycopsida, Sphenopsida and Pteropsida, the last-named being a group which will appear heterogeneous to many botanists. The descriptions of the various phyla are excellent, and include some account of fossil representatives and of the cytology. As the field covered is so wide, it is, however, inevitable that some aspects should be treated very briefly. As might be expected from the research work of the authors, the chapters on the Gymnosperms and Angiosperms are particularly interesting and lucid. Many references are made throughout to standard works and other literature, and the references are listed alphabetically at the end of each chapter.

The book is fully illustrated by line drawings and photographs. For the most part these are excellent and closely related to the text. No magnifications are, however, given for any of the figures, and in some instances the specific name of the plant illustrated is omitted from the legend. These omissions tend to lessen the value of otherwise excellent illustrations. Many of the line drawings are described as being "redrawn" from various sources when it would have been better to use the phrase "based on". This is so in examples where the copying has not been precise (though not misleading), or where shading has been introduced or a pictorial background added. In one instance, photographs are said to be "redrawn".

The book may be recommended to students as giving a good general picture of evolutionary trends within the Tracheophyta. At the same time it indicates, though perhaps without sufficient emphasis, the difficulty, and often the impossibility, of reaching final conclusions in phyletic morphology. The references to recent work on morphogenesis, experimental morphology and cytology should be of value to students as indicating lines of research of great intrinsic interest apart from their possible bearing on the many persisting problems—or "abiding mysteries" as the authors call them—of comparative morphology.

S. Williams

ELECTROPHORESIS IN THEORY AND PRACTICE

The Principles of Electrophoresis

By René Audubert and Serge de Mende. Translated by A. J. Pomerans. Pp. viii + 142 + 16 plates. (London : Hutchinson and Co. (Publishers), Ltd., 1959.) 25*s*. net.

Electrophoresis

Theory, Methods and Applications. Edited by Milan Bier. Pp. xx + 563. (New York : Academic Press, Inc. ; London : Academic Books, Ltd., 1959.) 15 dollars.

IT must be admitted that many people who employ electrophoretic methods have little more than a passing acquaintance with the principles involved in the techniques they are using. These two books should enable everyone to know what they are doing, whether they undertake moving-boundary, paper or most other variations of electrophoresis. Both these books cover the whole field and so conveniently bring together information which hitherto has been scattered.

Audubert and de Mende's volume forms a useful theoretical introduction ; the principles of electrophoresis are set out clearly and systematically and the translation has been well done. Beginning with the general properties of electrolytes, the book passes on to colloidal systems, electrokinetic potential and electrophoresis. Then follow sections on the principles

underlying moving boundary and paper electrophoresis. Finally, other zone methods and applications are described. Unfortunately, with one exception (and that is a review article), all references are no later than 1954; consequently some of the matter in the last part of the book is somewhat out of date and some recent important developments are not covered. Part of the section on applications is rather sketchily done, and brief descriptions are not supported by references (pp. 137–138). The book's chief value lies in its theoretical exposition, but there are one or two flaws. The dissociation of proteins (p. 13) and of amino-acids (p. 70) is represented by concepts which have long ago become obsolete; even more serious is the last paragraph on p. 70, which fails to recognize that an ampholyte can have a net charge (and therefore move as a single zone towards an electrode) when it contains both positively and negatively charged groups. This is surprising, especially as, two pages further on, the concept of net charge is recognized. There are a few less serious errors such as "sulphate" for "sulphide" in Fig. 77 and p. 106, and in Fig. 78 the photometer tracing is reversed relative to the strip. Nevertheless, I believe that this book will prove to be of great value to most people who are using electrophoretic methods, and if, as I hope, it reaches a second edition, opportunity should be taken to rectify the few errors and include more up-to-date matter.

The book edited by Bier treats in greater detail the theory and practice of electrophoresis. It consists of a series of articles on selected topics, each written by experts. The first two, by Overbeek and Lijklema and by Linderstrøm-Lang and Nielson, deal very fully with the fundamentals of electric potentials in colloidal systems and acid-base equilibria of proteins. There are three excellent chapters on moving boundary electrophoresis (Longsworth on theory and practice; Brown and Timasheff on applications to protein systems). Paper electrophoresis is covered well by Wunderly, and Kunkel and Trautman deal with other zone electrophoretic methods, including important recent developments such as starch gel, cellulose column and immuno-electrophoresis. Applications of zone methods are covered by Wieland. Bier's article deals with preparative electrophoresis without supporting media and is an excellent survey of methods depending on density gradient, electrodecantation, electrophoresis convection and forced flow electrophoresis. An addendum to this section describes electrophoresis in non-aqueous solvents and gives the impression that this is a very recent development, but I think that Karagounis (*Nature*, **161**, 855; 1948) should receive credit for originating the method described. Of particular interest to those working in the medical field is Moore's article on clinical and physiological applications. Britten and Lauffer give a fascinating account of electrophoresis of viruses, bacteria and cells, and of the microscopic method of observation.

There is a certain amount of overlapping, probably difficult to avoid in a book of this nature, and it might have been a more logical arrangement for Wieland's contribution to have followed that of Kunkel and Tiselius, and for Brown and Timasheff's chapter to have followed Longsworth's. But Dr. Bier and his collaborators are to be congratulated on an outstanding contribution to the literature of electrophoresis. There is little doubt that the hope expressed by him in his preface that this would be an authoritative work has been realized.

R. CONSDEN

A SOURCE BOOK OF FUNGAL PHYSIOLOGY

Physiology of Fungi

By Prof. Vincent W. Cochrane. Pp. xiii+524. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 78*s*. net.

DURING the past thirty years interest in physiology and biochemistry of the fungi has been increasing, but it has received additional encouragement by the publication in the last ten years of several books. These have brought a mass of short papers and accounts of experimental work within the easy reach of all biologists. Each of these books has treated its subject in a different way, some giving emphasis to chemistry or to functional physiology, others perhaps attempting to review the whole subject at an undergraduate-level. The result has been wholly beneficial to mycology itself, for it is now possible for those interested in particular in taxonomy, ecology, pathology or genetics of the fungi to apply to their own work the information gained by laboratory study of physiology. Further, the yeasts and a few moulds are no longer the only polite subjects of physiological and biochemical inquiry among the fungi, but have come to be seen for what they often are, rather specialized organisms.

Prof. Cochrane has had several aims in preparing his book, and these he has achieved with skill. He has attempted to review the literature on fungal physiology particularly mentioning work done in the past thirty years, to emphasize those results of a truly experimental and quantitative nature, and to show clearly what parts of the subject present outstanding problems which still require quantitative investigation. Certain aspects of physiology have been intentionally omitted, such as the interaction of organisms with one another. This subject is so vast that the need for its omission is easily understood.

The book as a review of the available information is remarkable for the number of works to which it refers. In 379 pages of text some $4{\cdot}5 \times 10^3$ references are quoted which are grouped at the end of each chapter so that their use is greatly facilitated. Although they are so numerous, they still only comprise a selection made by the author from a much greater number, and this itself indicates the magnitude of the subject of fungal physiology. The selection has been good, and as long as one remembers that emphasis has been given to biochemical rather than physiological and to quantitative rather than qualitative information, the book is greatly improved by it. Each reference does not, of course, receive detailed appraisal, but the important and difficult aspects of each problem receive comment and criticism designed to place them in proper perspective. At times the space allotted to important subjects is a little too restricted. For example, the general remarks on metabolism of oligosaccharides in Chapter 5 are unlikely to be easily understood by anyone meeting the subject for the first time.

The book as a whole is good and will be found especially valuable as a reference book for all those interested in fungal physiology. It may be used to obtain a short critical survey of a problem and also as a guide to references from which fuller details may be obtained.

J. L. HARLEY

A UNIVERSITY OF GRADUATE STUDIES*

By Dr. DETLEV W. BRONK, O.B.E.(Hon.), For.Mem.R.S.
President of the Rockefeller Institute, New York, and of the U.S. National Academy of Sciences

SINCE the beginning of the University of Bologna nine centuries ago, many universities of many kinds have been created in many places; all have been created to satisfy the same deep desire of men to learn and teach. Because universities satisfy that desire, which is unique to human kind, universities have been among the most enduring of human institutions. Their vitality has been attested by their ability to sustain their basic purpose within changing patterns of structure and of action. Various and changing circumstances have evoked universities of various characteristics.

Since the beginning of the Rockefeller Institute, only half a century ago, it has provided rich opportunities for men to learn. It has been a community of scholars who were privileged to explore the frontiers of natural knowledge. Our predecessors have left us a heritage of traditions of intellectual excellence and adventure. They laid strong foundations for a house of learning.

Five years ago we determined to build further on those foundations, so that we might welcome our young successors to this community of scholars and gladly teach and guide them as they prepare for scholarly careers. To-morrow we will speak of new buildings of glass and stone, of modern art and natural beauty. To-day I speak of building an academic structure in which youth may learn from the elder, and the elder have the intellectual stimulus of the younger.

As we have extended the scope of the Rockefeller Institute and assumed the new responsibilities of a School of Graduate Studies, we have thought deeply of our obligations to satisfy the traditional standards of institutions of higher learning. I have personally felt that sense of responsibility keenly, for my life and those of my forebears have been lived in academic places which we prized highly.

I would here quote, as I will do again, from Rashdall of Oxford, the great biographer of European universities in the Middle Ages: "It behooves us not", said he, "to lose or lower the ideal of the university as the place *par excellence* for professed and properly trained students, for the highest intellectual cultivation, for the advancement of science, and not merely for its conservation or diffusion. . . . Whether a particular institution should or should not be called a university may seem by itself to be a little thing, but the name has got to be associated with education of the highest type. It is by no means essential that all should conform exactly to the same pattern. The two most essential functions which a true university has to perform, and which all universities have more or less discharged, amid the widest possible variety of system and method and organization, are to make possible the life of study, whether for a few years or during a whole career, and to bring together during that period face to face, in living intercourse, teacher and teacher, teacher and student, student and student".

Familiar though these functions be, it is appropriate, I think, to state them and restate them in these times of turmoil. The tranquil, contemplative life is harassed and eroded by the busy demands of the moment. The explosive growth of populations requires much wisdom for the preservation of the precious intimacy of relation between a scholar and a scholar and between scholars and those in other walks of life.

Those functions are two of the objectives of the Rockefeller Institute. The first need not be justified to an academic audience such as this, but the significance of that function is less apparent to many all about us who value academic institutions most or only for the training that they gave as preparation for the performance of specific tasks. They value research as discovery of useful knowledge; too few, unfortunately, perceive research as a happy, exciting adventure that gives vitality to our culture.

The Rockefeller Institute is fortunate in its heritage of advice from its founder, who took a longer view and often said to those who studied here, "Don't be in a hurry to produce anything practical. If you don't, the next fellow will. You, here, explore and dream".

It is our purpose to follow that advice and make the Rockefeller Institute a place in which to live a life of study. Though that be a privilege which is sought by many, the Institute will severely limit the number of those who study here, so that those who do so may come together, face to face, in 'living intercourse'. Such limitation is not easy, for refusal never is, and in the United States, all too often, size appeal is an overpowering temptation to sacrifice excellence for numbers. There is appropriate wisdom in the words of Ellery Sedgwick, who said: "One can influence many by inoculating the influential few", as did *The Atlantic Monthly*, of which he was then editor.

Specialization seems necessarily to follow increase of knowledge. New specialties and specialists seem to breed new university departments, and so the scope of universities seems necessarily to grow, and thus to satisfy the needs of a more complex civilization. But some graduate schools could become superlatively good by restricting the scope of their endeavour to immediately related fields.

That was said to me by Abraham Flexner as I began my professorial career in 1926. That year he, also, wrote in *The Atlantic Monthly* some words which I would read as these: "The range of certain universities could be greatly reduced. Moreover, modern science and scholarship being what they are, universities could be very irregular affairs. No single science can be completely represented anywhere; still less, all sciences: and institutions most concerned with science would almost inevitably be less adequately

* Substance of an address delivered on May 21 at the first Rockefeller Institute Convocation for Conferring of Degrees and Dedication of New Buildings (see also *Nature* of June 13, 20, 27 and July 4, 1959).

developed on the humanistic side. Nor does it greatly matter: the very incompleteness of single institutions will force all real universities in the higher sense to view themselves as parts of one great organic whole".

Perhaps Flexner read Rashdall also, for there I find: "The word *universitas* is one to which a false explanation is often assigned for polemical purposes by controversial writers, while the true explanation of it at once supplies us with a clue to the nature and historical origin of the institution itself. The notion that a university means a school in which all the faculties or branches of knowledge are represented has indeed long since disappeared from the pages of professed historians, but it is still persistently foisted upon the public by writers with whom history is subordinate to what may be called intellectual edification".

"However imposing and stimulating may be the conception of an institution for the teaching or for the cultivation of universal knowledge, however imperative the necessity of such an institution may seem at times to be, it is one which can gain little support from the facts of history. To glance into any collection of medieval documents reveals the fact that the word 'university' means merely a number, a plurality, an aggregate of persons".

One of the most needed functions of a school of graduate study in these days of specialization is to foster broad foundations upon which a man may build competence to deal with problems yet undreamed of. Broad foundations of interest in many related fields of science and wide knowledge are essential to a scientist who would be a scholar.

Sir George Trevelyan, a Master of Trinity College, Cambridge, in speaking of the friend of whom he then was writing, said: "He was an outstanding example of a type that has always specially attracted me: the specialist who has a wide outlook, broad knowledge, and warm enthusiasms outside his own subject as well as in it, and more particularly, a man, he was, whose mind has been trained in the splendid discipline of a science, but whose heart and eyes take also delight in the triumphs of art, in the history of man, in the beauties of Nature. Such a man is about the best thing that our modern civilization can produce".

We hope that in the Rockefeller Institute we may fit students to become men such as the one of whom Trevelyan spoke. We would relate science to all other forms of creative endeavour. We will strive to interpret science as a great Odyssey of the human spirit. In order to do so we will draw upon all the resources of the learned world that may be available to us in order to emphasize the proper place of science in the total structure of man's creative effort. We seek to make an environment in which men and women can pursue knowledge not as a grim undertaking, not as an undertaking for the achievement of immediate, practical, ends, but as a happy, joyous pursuit of knowledge which will enrich all their lives, and the lives of all those about them.

EDUCATION FOR THE AGE OF SCIENCE

AN outstanding statement on the place of education in the life of a nation has recently been published by the Science Advisory Committee to the President of the United States of America. Issued with the warm encouragement of the President, the report sets out the national goals for strengthening science and engineering education and urges support by all American people to meet these goals (see also p. 81 of this issue).

The American outlook is conditioned by the traditional dedication to the proposition that most of her children shall have a long educational experience, that no child shall be deprived of the fullest opportunity to develop his own talents, and that the people of each local community shall, to a large degree, be autonomous in the decisions they make about the education of their own children. In theory it is intended that the brilliant child shall be able to develop brilliantly; that the slow or backward child shall be nurtured patiently; that the artisan shall not be considered inferior to the intellectual because he is an artisan, if only he is a good one; that no one shall be condemned to a lowly position or elevated to a high one by the mere circumstance of the wealth, power or prestige of his ancestors.

These are the premises, and most American educational policies are based upon them. Yet there are inconsistencies. Very few Americans, for example, would insist that the words of the Declaration of Independence require that all Americans be equally competent in intellectual matters and that they should, therefore, automatically pass together from grade to grade in school. Occasionally this seems to be the policy.

Americans do not really think that educated people are dangerous or silly—yet the terms 'egg-head' and 'intellectual' are not always terms of approbation. Americans occasionally act as though they feared the word 'excellent', especially as applied to mental achievement. In other words, the practices do not always live up to the ideals.

After a close and penetrating analysis of the American educational system, the Committee defines certain goals the attainment of which would strengthen science and engineering education in the United States. The goals are based upon the belief that a changing civilization will demand an even greater devotion to learning and a greater pride in intellectual achievement. "The profound effects of recent advances in science and technology demand that scientific literacy be far more widespread among the American people if we are to solve the problems of this age".

The Committee recommends that:

(*a*) Americans should attach greater value to intellectual excellence.

(*b*) Every school and college should re-examine its curriculum to make sure that in every aspect it is giving adequate challenge to the intellectual capacities of its students.

(*c*) Much more should be done to enhance the prestige of the teacher and to provide him with more effective support in his efforts to improve the effectiveness of his teaching.

(*d*) Educational programmes should be adapted to the widely varying competence of students, and especially to the needs of the most gifted students.

(*e*) Scientific education at all levels should be improved to give better understanding of science to the non-scientist as well as to discover and stimulate more individuals who have the talents to become scientists and engineers.

To attain these ends four major areas need specific and urgent attention throughout the educational system. These are the curriculum and content of courses, the quality and effectiveness of teachers, the recognition and encouragement of students, and the development of intellectual leadership.

The quality and content of the curriculum are central in education. At every level in the school, college, and graduate school the curriculum must provide the basic educational materials required of all students, plus the broad selection of opportunities appropriate to the student body involved. For those at higher levels in the educational system, it becomes increasingly important that the course content give recognition to the range of abilities of individual students, and, of equal importance, that each student be guided to the subjects best suited to his own innate talents.

Especially in rapidly changing fields like science and technology, curricular changes must occur decade by decade, and even year by year. At the secondary school level there are problems of balance between vocational and academic courses, and, at the college and university level, the problem of balance between the sciences, the humanities, and the social sciences.

The Committee urges scientists and scholars to establish more intimate contact with experienced teachers at all levels, so that the curricula and teaching and learning aids in schools, colleges and universities may take account of the new facts and the new points of view that scientific progress has revealed.

The Committee also recommends that a research programme be established by an appropriate foundation or agency in which scientists, scholars and teachers co-operate to design more adequate curricula planned to give all educated citizens an adequate introduction to those areas of science and technology essential to an understanding of the problems of a modern society.

Since the content of courses in mathematical and scientific fields at both the secondary and undergraduate college level does not adequately recognize scholarly advances in these fields, the Committee recommends that present efforts be aggressively pursued and substantially expanded in bringing together leading scientists, scholars and teachers in these various subject-matter fields to seek :

(1) To bring the course content in each subject at each level into line with the most modern scholarly research in its field, consonant with the level of instruction.

(2) To outline, write, publish, and revise the necessary text-books and auxiliary reading materials to achieve these objectives.

(3) To develop and supply adequate teaching and learning aids of all appropriate kinds, including motion pictures, television, tape recordings, slides, and other audi-visual materials designed to aid the student in understanding the subject more thoroughly, and especially to relieve the teacher of unnecessary burdens of preparation and instruction, and to enable the outstanding teacher to reach a much larger number of students.

(4) To develop and supply laboratory equipment and materials for science courses together with the necessary manuals and reading materials to make the laboratory and field work a far more meaningful, useful and exciting aid to student and teacher.

On the quality and effectiveness of teachers, the Committee would like scientists and engineers in universities and industries to establish organized programmes of collaboration with high-school and college teachers in order to reduce the gap in communication and understanding between these groups, rendering assistance and providing teaching material to teachers and their students, and bringing high-school and college students and teachers into more direct contact with scientific and scholarly work in universities and industry. The economic and social status of teachers at all levels should be improved, enabling them to devote more of their working time to teaching tasks rather than administrative chores, and allowing them more time for preparation and study in their chosen fields. Private and government agencies should evolve State and national programmes for providing substantial rewards, prizes, and other recognition to outstanding teachers in both elementary and secondary schools.

A research programme should be sponsored on a national scale to bring together a key group of scientists and scholars to collaborate with teachers and educators on the problem of designing more adequate curricula for the education of high-school and college teachers, especially in the sciences and mathematics, with the aims of reducing the alleged conflict between subject-matter and methodology, making teacher training programmes more attractive to the best students, and bringing about a better understanding between scholars, scientists, teachers, educators and the public in regard to the philosophy, goals, and methods of the educational system.

With the assistance and encouragement of the universities, the nation's best scholars should join the nation's great teachers in the task of determining how the great teacher may be brought before an even larger number of students.

To recognize and encourage students, the Committee asks the American people to accept as a national goal lifting the student performance to higher levels of excellence by greater motivation and by the provision of rewards for intellectual achievement and more adequate and extensive opportunities and challenges to the highly gifted student. A nation-wide effort should be made to pay more attention to the academically talented students (that is, those in the upper 15–20 per cent of the age-group in intellectual ability) and to the unusually gifted students (that is, those in the upper 3 per cent of the age-group). Such an effort should involve citizens, school-boards, parents, teachers, together with State and national agencies, public and private. Talented students should be recognized at an early age and given guidance and counsel in planning their educational programmes and in preparing for and choosing college and university work. These gifted students should be given the necessary help in financing their educational programmes in high school as well as in college and in graduate school. Such students should be rewarded and encouraged for their achievement in order that they may take pride in intellectual excellence, even at an early age.

In considering the development of intellectual leadership, the Committee concludes that the intellectual, cultural and material advances of any society depend upon the quality of its leadership—upon its scholars, teachers, lawyers, industrial leaders, scientists, engineers, doctors, and other professional people. "These individuals are stimulated and educated in the colleges, universities and graduate schools of the country. To stimulate and educate the intellectual leaders of the future, we maintain a wide variety of colleges and universities located in every region of the United States. These institutions are continually seeking to improve the quality of the intellectual experience which they offer to qualified students in all fields. All, however, need much more help and support in these efforts".

The Committee is concerned about the slow progress which many of these institutions seem to make in their dual task of providing all their students with an adequate introduction to science and technology and the part they play in modern society, and providing adequate educational programmes to those with the talent for and interest in achieving professional careers in science, engineering and technology.

The separate liberal arts college and the college of arts and sciences of the great universities constitute basic training grounds for most of the leaders of to-morrow. There are overwhelming reasons why such citizens should acquire a reasonable introduction to the principles of science and technology on which the modern industrial society is based. Scientists and scholars should give greater attention to assisting the undergraduate colleges in providing adequate programmes in these fields.

From these conclusions it is specifically recommended that the curricular revision programme now being developed for high-school science courses be extended to undergraduate college courses in science and mathematics; aid be rendered to liberal arts colleges in examining their curricula to assure that they are adequately providing for scientific education of the non-scientist as well as of the future scientist or engineer; improving the number and quality of schools of science and engineering should be accepted as a national goal; university graduate schools in science and engineering should be enlarged in number and improved in quality, far greater emphasis being placed upon graduate work in engineering; the engineering colleges of the country should collaborate to improve and modernize their courses in engineering to ensure that able students are attracted to these courses and that they are given adequate training to meet the engineering and technological problems of to-morrow; government agencies concerned with research in science and engineering should re-examine the terms of their research support to educational institutions, with the view of avoiding placing a financial burden or penalty on such institutions by inadequate coverage in research contracts or grants of costs properly chargeable as overhead and for management allowances. Without serving as a subsidy in any way, proper handling of these fiscal matters can make certain that the research support will not affect adversely the opportunity to use the research effectively for the education of students, for the attraction and retention of able faculty members, and for the release of teachers and students from burdensome administrative and fiscal restrictions.

CURRENT TRENDS OF STRONTIUM-90, STRONTIUM-89 AND CÆSIUM-137 LEVELS IN MILK

By W. ANDERSON, L. K. BURTON and J. O. CROOKALL

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IT is widely recognized that milk is an important proximate source of the long-lived fission products present in the human body. In a recent communication[1] we summarized the main information available on the levels of radiostrontium and radiocæsium occurring in milk produced in Great Britain. In the case of strontium-90, the evidence pointed to some regional and seasonal variation, but viewed over the period 1955 until May 1958 it appeared that the levels had remained fairly steady. The picture for cæsium-137 was similar but was complicated by the additional deposition resulting from the Windscale accident. A recent report by Booker[2] extended the available information on cæsium-137 levels, and, in addition, showed that substantial increases of these levels occurred during June 1958 in milk drawn from nine different areas. This article reports detailed experimental observations made by us on the levels of strontium-90, strontium-89, and cæsium-137 occurring in milk produced in west Cardiganshire (Felinfach Creamery) throughout 1958.

The samples referred to in this article form part of the series described previously[1]. It was not possible to obtain dried-milk samples from the Creamery after September 1958 but the series was continued by employing liquid milk samples. To ensure that the sampling procedure remained as fully representative as hitherto, arrangements were made at the Creamery so that the final liquid sample was prepared from numerous periodic samplings of a total day's production. The methods of measurement used were also essentially those described previously. In the case of cæsium-137 in liquid samples, the measurements were conducted on the ash, after a number of tests had shown that no significant loss of this nuclide occurs during either the evaporation or ashing procedures employed.

As before, the samples were received at weekly intervals and measurements made on bulked samples, compounded from four consecutive weekly samples. The values obtained for 1958 are shown in Fig. 1. The main features of the results for each nuclide studied are as follows:

Strontium-90. As shown in Fig. 1*a*, the strontium-90 levels started to rise in April from a steady winter value of about 7·5 S.U., reaching values of 16·5–16·9 S.U. during May–July (1 S.U. = 1 μμc. strontium-90/gm. calcium). The levels are in the region of 14 S.U. during the autumn but rise again to 16·6 S.U. during November. The levels found for January and February 1959 were 13·4 and 15·3 S.U., respectively. It should be noted that the values found during January–April reflect levels present in winter fodder while later values until December reflect levels occurring in the pastures.

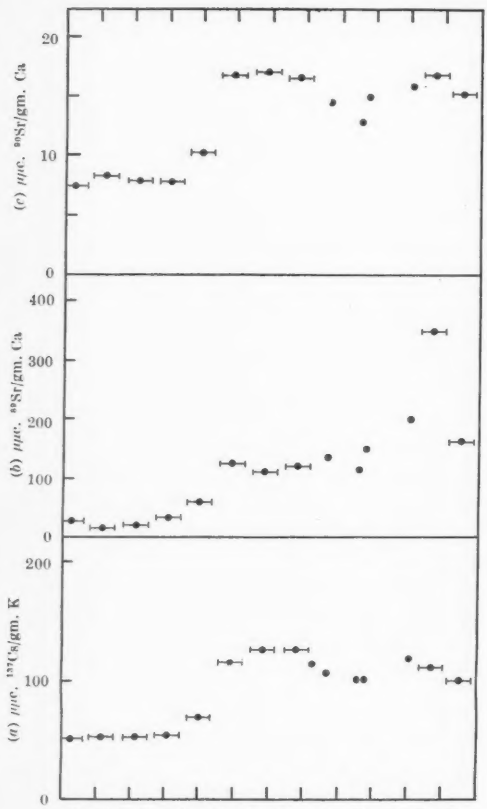

Fig. 1. Levels of fission products in milk from Felinfach, west Cardiganshire, Wales (1958)

The values recorded after April 1958 are substantially higher than those found previously by us[1] for milk produced at Felinfach and by Bryant *et al.*[3] for milk derived from neighbouring pastures (Carmarthen). Taken together the Felinfach and Carmarthen results gave a picture of fairly steady levels in the range 5·4–8·4 s.u. over the period October 1956–April 1958, with a temporary rise to values around 10 s.u. during October–November 1957. A comparison of the mean level, 15·7 s.u., for May–August 1958 (Fig. 1*a*) with the corresponding level, 7·0 s.u. at Carmarthen in 1957[3] shows the extent to which the levels of strontium-90 increased in the pastures of this region between 1957 and 1958.

Strontium-89. The occurrence of strontium-89 in milk, at levels such as those shown in Fig. 1*b*, is a reflexion of recent weapons testing. It will be noted that the November level is approximately three times higher than the mean summer level, although there is no similar increase in strontium-90 levels. This is due to the fact that strontium-89 present in deposited fission products is derived mainly from the tropospheric component of explosion debris, whereas, strontium-90 is mainly deposited from a stratospheric reservoir, depleted in strontium-89 by natural decay[4]. The mean November 1958 strontium-89 value (310 μμc./gm. calcium) is comparable with that found in October 1957 (280 μμc./gm. calcium)[1].

The strontium-89/strontium-90 ratios are listed in Table 1 as average values for each month during October 1957 to February 1959. These values may be compared with the strontium-89/strontium-90 ratios, corrected to mid-month, reported by Stewart *et al.*[5] for rain-water collected at Milford Haven, which lies 50 miles south-west from the centre of the Felinfach area. This comparison shows that, during pasture feeding periods (Oct.–Nov. 1957; May–Aug. 1958) the monthly ratios for milk range from 46 to 86 per cent of the corresponding ratios for rain-water, the average value being 70 per cent. This is consistent with the results of Bryant *et al.*[6], who found strontium-89/strontium-90 ratios in herbage equal on average to 65 per cent of those in rain-water. The strontium-89/strontium-90 ratios for radiostrontium in herbage and milk are smaller than the values in rain as a result of the mixing of current fall-out with earlier fall-out, depleted in strontium-89.

Cæsium-137. On inspection of Figs. 1*a* and *c*, it will be seen that the trend of cæsium-137 levels in these samples follows closely that of strontium-90. The cæsium-137/strontium-90 ratios throughout the year are similar to values obtained for samples produced prior to the Windscale accident. This result confirms the suggestion made earlier[1] that cæsium-137, deposited on these pastures from the Windscale pile, is no longer being incorporated in the grass.

The maximum error on cæsium-137/strontium-90 ratios, calculated from the values shown in Fig. 1, is estimated to be ± 15 per cent. The ratios (expressed as μμc. cæsium-137/l./μμc. strontium-90/l.) range, for bulked samples, from 8·7 to 10·5 (mean value = 9·5). Within the limits of experimental error, the ratios may therefore be regarded as constant. The weekly variations of cæsium-137 levels during May–August are shown in Fig. 2, together with a breakdown of strontium-90 levels for the peak in June. It appears from these results that for individual samples the cæsium-137/strontium-90 ratio varies to a small extent, but that in bulked samples, covering a period of a few weeks, the fluctuations tend to average out.

As noted recently[7], a practical advantage would be gained if the comparatively straightforward estimation of cæsium-137 in milk could be used to provide an indirect estimate of strontium-90. It appears that, for the present series of samples, this approach would be reliable if supported from time to time by direct strontium-90 estimations. It is possible, however, that the indirect estimations of strontium-90 could be misleading for samples derived

Table 1. Strontium-89/Strontium-90 Ratios in Milk (Felinfach)

Month	Strontium-89*/ strontium-90	Month	Strontium-89*/ strontium-90
1957		1958	
October	29·0	July	7·7
November	16·6	August	~ 8·7
December	5·8	September	~ 9·8
1958		October	—
January	3·7	November	18·8
February	2·5	December	11·0
March	3·4	1959	
April	5·8	January	6·7
May	7·2	February	4·9
June	7·2		

* Computed for each month from Figs. 1*a* and *b* with due allowance for overlap of values for bulked samples and calendar months.

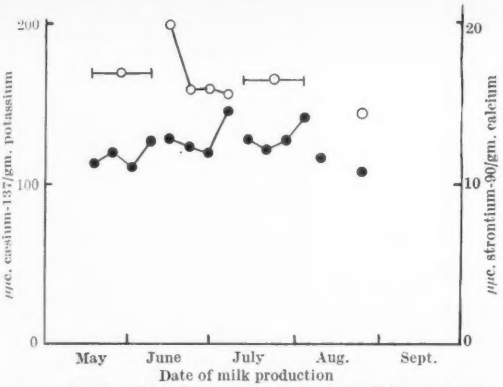

Fig. 2. Cæsium-137 and strontium-90 levels in Felinfach milk during May to August 1958. ○, strontium-90; ●, cæsium-137

from pastures which are more intensively cultivated than those in the Felinfach area[8].

Detailed accounts of the world-wide deposition of long-lived fission products have been published by Stewart *et al.*[4,5,9], giving a continuous picture of the accumulation of these radionuclides on the ground. In attempting to estimate the future trends of fission product-levels in milk it is important to know how far the levels are determined by the rate of deposition, on one hand, and the cumulative deposition, on the other. Previous reports on milk produced in Great Britain suggest that the levels of both strontium-90 and cæsium-137 depend more on the rate of fall-out than on total deposition[1,3,10]. The present results throw further light on this complex question.

The most recent report by Stewart *et al.*[5] shows that the rate of deposition in Great Britain during the summer of 1958 was considerably greater than during previous summers. It appears further that this increase was due in substantial measure to the occurrence of unusually high summer rains. Using the values reported for specific activity in rain-water at Milford Haven, together with information on the rainfall at six meteorological stations in the Felinfach–Carmarthen area, we estimate that the average total strontium-90 fallout in this region for May–August 1958 was 2·8 times the corresponding value for1957. A similar estimation shows that the cumulative total rose between June 1957 and June 1958 by a factor of 1·5. The results for strontium-90 in Felinfach–Carmarthen milk provide firm evidence that the average level during May–August 1958 was approximately double the corresponding 1957 level (comparing 15·7 s.u., 1958, with 7·0 s.u., 1957, gives a factor of 2·2). It will be seen from these figures that the increased levels in milk could be fully accounted for by the increased rate of fall-out, although an appreciable dependence on the cumulative total cannot be excluded. Further information on the relative importance of these different factors is given by the strontium-89 results, as discussed below.

It is not clearly known what fraction of the strontium-90 present in herbage enters the plant by direct uptake through leaves and stem, as opposed to entry from the soil via the root system[8,10]. It appears that a large fraction of the strontium-90 deposited on the ground is retained by many soil types in the top few inches of the soil, but again it is not clear what fraction of the cumulative activity is available to the plant. The present results show that the strontium-89/strontium-90 ratios in milk, produced during pasture-feeding periods, are on average at least 70 per cent of the values which would occur in the herbage if there was no contribution from the soil reservoir. The ratios in milk during May–August 1958 are approximately five times the corresponding ratios for the cumulative totals of strontium-89 and strontium-90 in the soil[5]. A simple calculation based on these results shows that less than 35 per cent (that is, 5·5 s.u.) of the strontium-90 in the milk produced during May–August 1958 may be derived from the cumulative deposit in the soil. The results do not preclude the possibility that all the radiostrontium enters the herbage via the soil but, on that basis, only the deposit of the preceding 4–5 months would be involved. It follows from these arguments that the 1958 increase of strontium-90 levels in the Felinfach samples is related mainly to the corresponding increase in fall-out rate. Consequently the rise in levels should be regarded in terms of a fluctuation rather than an increase to higher stable levels.

The striking parallel in the trends of strontium-90 and cæsium-137 (Fig. 1) strongly suggests that rate of fall-out is equally important for both nuclides. This result is in keeping with previous indications of the importance of fall-out rate in the case of cæsium-137 levels in milk sampled both in Great Britain[2] and the United States[11]. Reports on the trend of strontium-90 levels in milk produced in the United States have tended to link the levels with the cumulative fall-out[12,13,14]. It is clear, however, that comparatively large, short-term fluctuations, indicative of a high dependence on fall-out rate, have occurred in these levels[14].

It is not possible to forecast accurately the levels of strontium-90 and cæsium-137 which will occur in milk during the current year, since neither the 1959 rainfall nor the influence of the 1958 series of weapons tests on the specific activity of the rain can be exactly predicted. Provided that no further testing occurs, the levels of strontium-89 in milk produced after the summer of 1959 might be expected to be less than one-tenth of the levels occurring during November 1958.

We wish to acknowledge our indebtedness to Prof. W. V. Mayneord, director of the Physics Department, Institute of Cancer Research (Royal Cancer Hospital), for his guidance and encouragement throughout these studies.

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OBITUARIES

Mr. R. P. Howgrave-Graham

By the death on March 25 in his seventy-ninth year of Robert Pickersgill Howgrave-Graham, a remarkable life devoted to such varied subjects as electrical science, horology and archæology was brought to its close.

Howgrave-Graham was born in Hampstead into a cultured family. His father was the first secretary of the Institute, now the Chartered Institute, of Patent Agents.

During 1896–99 Howgrave-Graham studied electrical engineering at Finsbury Technical College under Silvanus Thompson, whom he revered throughout his life as his teacher and his friend. Appointed a demonstrator upon the completion of his course, Howgrave-Graham began to assist Silvanus Thompson in his researches, to undertake teaching duties, and to experiment with Herzian waves and high-frequency electric currents. He showed himself to be an exceptionally lucid, sympathetic and enthusiastic teacher and an experimentalist of high ability.

In the years prior to the First World War, Howgrave-Graham was associated with Lodge and Muirhead in the perfection of the wheel coherer, and he devised during the same period a reed, or fork-maintained, phonic motor of relatively high power. During the War, Howgrave-Graham, who was not physically fit for active service, continued his teaching at Finsbury and engaged in various research projects for the Fighting Services. The sudden death in 1916 of Silvanus Thompson left him to carry on, practically single-handed, the teaching of physics and electrical engineering at Finsbury.

In 1919, Howgrave-Graham left the Finsbury Technical College and took up a similar lectureship at the Northampton Polytechnic, where he continued his teaching work until his retirement in 1945.

Within a few months of the end of the First World War, Howgrave-Graham became engaged in the important patent action resulting from the application of Fleming and the Marconi Company for an extension of the term of Fleming's main thermionic diode patent of 1904. He gave evidence in support of the De Forest Company.

Although a teacher of distinction and a contributor to the early development of wireless telegraphy, Howgrave-Graham's best-known work is not in the field of electrical engineering but in that of archæology. He became an acknowledged expert on medieval machinery and in particular on church clocks. His two greatest works in this field were his researches associated with the restoration of the Wells clock, now in the Science Museum, and the Salisbury clock, which was reinstated in the Cathedral in 1956. Howgrave-Graham's patient and accurate historical research on these clocks, which not only contributed notably to their restoration but also incidentally established their dates at 1392 and 1386, respectively, was a work of real scholarship.

Photography was, for him, handmaiden to archæology. The art of photographing the interesting and beautiful features of the architecture of medieval buildings was one at which he excelled and many of his photographs, some of striking beauty, have been reproduced in books on Gothic art.

Happily for him, retirement from teaching presented a unique opportunity to devote himself single-mindedly to his archæology. He was appointed as assistant keeper of the muniments at Westminster Abbey. There he carried out much skilful restoration work, including the reinstatement and preservation of the earlier funeral effigies which had suffered severe damage by water during an incendiary bomb attack. His work on the effigies of Edward III and Henry VII revealed that the features of these effigies were actual death masks.

Quiet, kindly and sensitive, Howgrave-Graham was endowed with courage and perseverance and above all with the spirit of inquiry. There was, however, something more which made him the delightful and lovable character which he was. He enjoyed sharing his discoveries, he had a keen sense of humour and he never took himself too seriously. Howgrave-Graham's sense of humour was part and parcel of his feeling for the quaint and the incongruous. Perhaps that is why he was so much in tune with the touches of humour of the medieval illuminator or stone mason.

Howgrave-Graham married in 1944 Miss Beatrice Purdy, who survives him. J. Greig

Dr. W. A. Hargreaves

Dr. William Arthur Hargreaves died at Adelaide on March 31 in his ninety-third year. After an outstanding scholastic career in the University of Melbourne, where he took degrees in arts, science and civil engineering, Hargreaves occupied a number of teaching positions in Victoria and Queensland between 1889 and 1916, when he was appointed director of the Department of Chemistry and Government Analyst for South Australia, a position he occupied until his retirement in 1932.

Although Hargreaves was an outstanding analyst and a capable research worker (he was awarded the D.Sc. of the University of Adelaide in 1916) his greatest contributions to chemistry in Australia arose out of his interest in the teaching of the subject and the part he played in the formation of societies for the promotion of the profession. He was a member of the Faculty of Science of the University of Adelaide for thirty-one years and served also on the Australian National Research Council and the Council of the South Australian School of Mines. He was an executive officer of the Society of Chemical Industry of South Australia throughout its short life (1915–19) and a foundation member of the Royal Australian Chemical Institute, of which he was president during 1919–21.

Outside his profession, Hargreaves's greatest interest was in motoring; he was the first person in Australia to obtain a driving licence and the first to register a motor-car in South Australia, holding the number plate S.A.1 from 1906 until 1955. In 1894, he married Camilla Maud Nicholls, of Melbourne, by whom he had a daughter. Both his wife and daughter predeceased him. Harold J. Rodda

NEWS and VIEWS

Psychology at Sheffield : Dr. H. Kay

Dr. H. Kay, at present lecturer in experimental psychology at Oxford, has been appointed to the newly established chair of psychology at Sheffield. Dr. Kay read psychology after the English Tripos at Cambridge and for a number of years worked in the Nuffield Unit for research into problems of ageing at the Psychological Laboratory there. During this time, he gained considerable experience of the application of experimental methods to the investigation of manual and other skills. He also took part in field work undertaken by the Unit and was a member of the Naval Medical Expedition to the Arctic in 1949. In 1951, he was appointed to his present Oxford post and played a large part in the development of the Honour School of Psychology, Philosophy and Physiology which was taking place at that time. During the period 1953–56 he led a small team with outstanding success in research sponsored by the Conditional Aid Programme into the fundamentals of industrial skills. He and his colleagues have since extended this work in fruitful directions. Dr. Kay recently spent a year at the National Institutes of Health, Bethesda. During his years at Oxford, Dr. Kay has been active not only in university but also in college teaching, and has latterly been tutor in psychology at Balliol and Merton.

Electrical Engineering in the University of Western Australia : Prof. A. R. Billings

Dr. A. R. Billings, who has been appointed professor of electrical engineering in the University of Western Australia, graduated from the University of London in 1949, taking his Ph.D. degree in 1957. During 1951–52 he worked as a scientific officer in the Royal Naval Scientific Service before being appointed lecturer in electrical engineering (electronics and communications) in the University of Bristol. His principal interests are in the band-width compression of speech, and in the less usual applications of semiconductors. His earlier work in the first field has resulted in the production of a vocoder which is both simpler and more efficient than the conventional vocoders; while his later work has been concerned with the development of a formant tracker, and a simple synthesizer to go with it. In the semiconductor field Dr. Billings's main interest has been in application of the Hall effect in the new semiconductor compounds. This has resulted in the production of a suppressed-carrier modulator with very low carrier leak, and of a Hall-effect correlator which, when used in conjunction with the early vocoder, has provided new information about the properties of speech.

The chair of electrical engineering in the University of Western Australia is newly established, and Dr. Billings will be the first holder. The research in which he has been engaged is individual work which can be carried on with small-scale apparatus, and he will take with him to Australia some of his equipment from Bristol.

Rockefeller Foundation Grants to C.S.I.R.O. (Australia)

The Australian Commonwealth Scientific and Industrial Research Organization has formed a new Division of Tropical Pastures with headquarters in Brisbane. Dr. J. Griffiths Davies, associate chief of the C.S.I.R.O. Division of Plant Industry and officer-in-charge of the Organization's Plant and Soils Laboratory, Brisbane, has been appointed first chief of the new Division, which will continue to work in association with its parent C.S.I.R.O. Division of Plant Industry. Establishment of the Division of Tropical Pastures reflects the Organization's appreciation of the importance of developing pastures in the summer rainfall areas of Australia, and of the scientific standing of the Brisbane group.

The Rockefeller Foundation has given 30,000 dollars for special equipment for the newly formed Division. The grant will help equip the new Cunningham Laboratory, which is nearing completion. The new laboratory is next to the University of Queensland at St. Lucia, near Brisbane, and will be the headquarters of the C.S.I.R.O. Division of Tropical Pastures. The Division will use its grant to purchase a mass spectrometer and equipment for work with radioactive isotopes. These will be used to expand the Division's work on nitrogen and phosphorus, which are the most important deficiencies in Queensland soils. Dr. J. G. Davies expects that research will make possible a great increase in the carrying capacity of Queensland's pastoral areas.

This is the third large grant that C.S.I.R.O. has received from the Rockefeller Foundation in recent years. Recently the Rockefeller Foundation gave 100,000 dollars for special equipment for the Organization's Divisions of Plant Industry and of Entomology at Canberra. The Foundation also provided 250,000 dollars towards the cost of the giant radio telescope which will soon be constructed at Parkes, New South Wales, for the C.S.I.R.O. Division of Radiophysics.

Radio Telescope for Australia

It has been announced that the contract for the Commonwealth Scientific and Industrial Research Organization's giant radio telescope, which is to be located at Parkes, New South Wales, has been placed with the German firm of Maschinenfabrik Augsburg–Nuernberg A.G. Dr. E. G. Bowen, chief of the Organization's Division of Radiophysics, has played a leading part in completing the design of the radio telescope. It is expected that the total cost of the project will not be far short of £A750,000. Donations towards this have already come from the United States (from the Rockefeller Foundation and the Carnegie Corporation) and from industry and from private donors in Australia. Work to prepare the site is already in hand, and a start will be made to erect the telescope about the middle of 1960. A feature of the telescope will be its radio 'mirror', a saucer-shaped bowl 210 ft. in diameter and covered in wire mesh. This 'mirror' will pick up radio signals

from the outermost fringes of the universe. It will be slightly smaller than that of the only other giant radio telescope at present in existence (at Jodrell Bank, England). However, the surface accuracy of the Australian radio telescope and the precision with which it can be pointed and driven will all be substantially higher.

Proton Linear Accelerator

The 50 million electron volt proton linear accelerator at the Rutherford High Energy Laboratory, Harwell, came into operation on July 12. This is the first accelerator at the National Institute for Research in Nuclear Science to come into operation. It will be used for nuclear research by physicists from universities, the Atomic Energy Authority and a resident team based at the Rutherford Laboratory. When in full operation it is expected to have a proton beam intensity many times greater than other accelerators of this kind. Because of the high intensity and very well-defined energy it will be possible to do experiments of great value in the study of the interaction between nuclear particles. The main parts of the accelerator were designed and constructed for the Atomic Energy Authority by Metropolitan Vickers, Ltd., in collaboration with a team of physicists and engineers from the Atomic Energy Research Establishment who also carried out basic development work on the accelerating structures, and were responsible for the other parts of the machine.

High-Pressure Oxygen and Radiotherapy

It is now well established that when certain cells are deprived of oxygen they become more radioresistant, and recent work has demonstrated a similar effect upon malignant cells. Thomlinson furthermore suggested that in some malignant tumours a proportion of the cells were deficient in oxygen, due essentially to an inadequate local circulation, which could lower their radiosensitivity. On this basis, Dr. I. Churchill-Davidson, Dr. C. Sanger and Dr. R. H. Thomlinson started in 1954 at the Radiotherapy Department of St. Thomas's Hospital a preliminary investigation of the effects of irradiating certain malignant tumours in patients breathing 15–20 times the normal amount of oxygen while in a pressure chamber, which had been designed and presented by Sir Robert H. Davis. To obtain adequate irradiation at a depth without severe skin damage, γ-rays from a cobalt teletherapy unit were used.

Preliminary results in the treatment of advanced carcinomas were encouraging, and in order to try to overcome the limitations of the early prototype apparatus a new unit, specially designed for this purpose, has recently been installed at St. Thomas's Hospital. Essentially, the unit consists of an aluminium pressure chamber, also presented by Sir Robert Davis, into which are led oxygen pipes and multiple leads which enable the patient to be kept under controlled anæsthesia and observed electronically, although not seen, during treatment. A twin-headed cobalt-60 teletherapy unit has also been installed, with this chamber, so designed in order to reduce the time of treatment to a minimum.

River Purification

The growth of population and industry has produced problems of river management which had not been foreseen and are not capable of immediate solution. Many of the worst cases in Britain are in areas where industry developed and population grew rapidly between 1750 and 1850; the seriousness of the problem was not appreciated until it had reduced many of the rivers to an appalling condition. It was, however, a very long time before it was appreciated that the effects of modern developments in industry and in urbanization on surface waters must be taken into account when plans for the future are being made. Even as late as the 1920's the establishment of the beet sugar industry in Britain gave rise to an alarming pollution problem which threatened to turn many of the rivers in our rural areas into a condition as foul and offensive as those in the old industrial areas. About the same time, the growth of road transport led to the use of tar as a surfacing material for roads and that gave rise quite unexpectedly to a pollution problem which could have had serious effects on fisheries had it not been tackled in time. From then on it began to be realized that the prevention of pollution was, in fact, a practicable proposition and was possible if those concerned, whether industry, local authority or river authority, appreciated the problems and discussed them with other water interests before the waste waters had to be discharged. Eventually, this arrangement became an integral part of the Rivers (Prevention of Pollution) Act, 1951, which provides that the consent of a river board is necessary to any new discharge made into non-tidal waters. According to F. T. K. Pentelow, of the Fisheries Department, Ministry of Agriculture, Fisheries and Food (*Science Progress*, 47, No. 185; January 1959), that change of policy seems to be having good results, for the very considerable industrial expansion which has occurred since the War has not, so far, given rise to pollution problems on anything like the scale it would have done one hundred years ago.

Federation of British Industries

In the forty-second annual report of the Federation of British Industries for 1958 (pp. vi+42. London: Federation of British Industries, 1959) it is stated that the gradual discontinuance of research on defence projects sponsored by Government departments has necessitated a fundamental appraisal of the future finance and organization of industrial research. Discussions at the National Production Advisory Council on Industry showed that the Government's plans put forward by the office of the Lord President of the Council required a detailed statement of industry's point of view. The Federation's Industrial Research Committee has already formulated an interim statement, which was submitted to the Advisory Council in June 1958, and is now undertaking a detailed study of certain aspects of British research practice in relation to methods adopted abroad. The report also notes the establishment by the Federation's Education Committee, in co-operation with representatives of the Publishers' Association, Aslib, the universities and the technical colleges, of a panel to investigate the alleged shortage of advanced British text-books.

Technological Education in Britain

The tenth annual report of the London and Home Counties Regional Advisory Council for Technological Education (pp. 28. London, 1958) covers the year ended August 31, 1958, and refers to a complete reorganization of the Council. Under its new constitution, the approval of location of courses under the Ministry of Education's Administrative Memorandum 545 will be carried out by the Distribution of

Courses Committee, and a sub-committee of this committee, which considered the future development of the Council's work, recommended that the help of advisory committees should be sought in considering what advanced educational facilities are required for specific industries and in suggesting future distribution of courses. A committee has been formed to consider the relation of the universities with the technical colleges. The regional academic board arranged a very successful one-day conference on "Science and the Nation: the Role of the Grammar Schools and the Technical Colleges". Of the 141 courses approved to start in 1958–59, 14 were in applied science and mathematics, and 74 in engineering; of the total, 36 were full-time and sandwich courses.

Smithsonian Publications

A LIST of Smithsonian Publications available for distribution on June 30, 1958, has been compiled by Eileen M. McCarthy (pp. vi+54. Washington, D.C.: Smithsonian Institution, 1958). The papers are distributed gratis, except where price is given, to applicants requiring the papers as an aid to their researches or studies. Justification is required if more than one copy each of ten publications is requested, and requests should be addressed to the Publications Distribution Section, Editorial and Publications Division, Smithsonian Institution, quoting the publication numbers in sequence. The publications are listed under some sixty-four subject headings, arranged alphabetically.

Pharmacy as a Career

THE latest booklet in the choice of careers series issued by the Central Youth Employment Executive (H.M.S.O., 9*d*.) describes the work of pharmacists in each branch of practice and indicates the qualities needed for the profession; information is also given about the educational qualifications and training required. The purpose of the booklet is to help boys and girls to decide whether they are likely to find a satisfactory career in this profession; in most cases the decision as to which branch of practice students should follow is best left until they have gone at least some way with their training and can properly appreciate the relative attractions of the various branches in which they can later specialize.

Institute of Physics "Notes for Authors"

THE Institute of Physics has recently published a revised edition of its 36-page booklet to assist authors and to serve as a work of reference for all those who wish to contribute to the Institute's publications. Under its new title, "Notes for Authors", it gives hints on the preparation of scripts and diagrams, on the layout of mathematics, the correction of proofs, and so on. In addition to a bibliography of reference books and works on technical writing, the pamphlet also contains lists of the spellings, symbols and abbreviations used by the Institute. Copies of this booklet are obtainable from the Institute of Physics, 47 Belgrave Square, London, S.W.1, price 3*s*. 6*d*.

U.S. National Academy of Sciences: Foreign Associates

THE following have been elected foreign associates of the U.S. National Academy of Sciences: Dr. V. A. Ambartsumian, director of the Byurakan Observatory in Erevan, Soviet Armenia; Sir Edward Bullard, assistant director of research in the Department of Geodesy and Geophysics, University of Cambridge; Prof. Max Hartmann, Max Planck-Institut für Biologie, Tübingen; Sir William Hodge, Lowndean professor of astronomy and geometry, University of Cambridge.

Birbal Sahni Memorial Medal

THE Birbal Sahni Medal for 1958 has been awarded to Prof. P. Maheshwari, professor of botany in the University of Delhi. This Medal was instituted by the Indian Botanical Society through a generous grant of 2,500 rupees made by Prof. T. S. Sadasivan of Madras in 1957 to commemorate the memory of the late Prof. Birbal Sahni. It is awarded every year to a distinguished Indian botanist for his contributions and services to botany in India. The first medal (for 1957) was awarded to Prof. M. O. P. Iyyengar.

United Steel Companies, Ltd.: Research Department

DR. K. J. IRVINE has been appointed deputy research manager of the United Steel Companies, Ltd. He has relinquished his present duties as head of the metallurgy section, which is to be reconstituted. Mr. J. D. Murray has been appointed head of a new section to be known as applied metallurgy, which embraces high-temperature metals, alloy development and welding. Mr. F. B. Pickering has become head of another new section on physical metallurgy, which deals with the more fundamental aspects of this subject.

Announcements

SIR JOHN RUSSELL, formerly director of the Rothamsted Experimental Station, has been elected a member of the Polish Academy of Sciences.

DR. D. J. PRICE has been appointed visiting professor of the history of science in Yale University for the academic year 1959–60. During the past year Dr. Price has been John W. Donaldson Fellow and member of the School of Historical Studies at the Institute for Advanced Study, Princeton, New Jersey.

MR. GWILYM HUGHES has been appointed to succeed Mr. Donald Hudson as president of the Pharmaceutical Society of Great Britain; and Mr. Tom Reid becomes vice-president in succession to Mr. Hughes. Mr. W. Spencer Howells is treasurer for the thirteenth successive year.

THE Royal Society of Edinburgh, 22 George Street, Edinburgh 2, has arranged to microfilm the thirteen volumes of the David Hume manuscripts. Copies of the microfilm will be available by purchase only, and libraries interested are invited to send forward their names, when further particulars will be circulated.

THE Journées Métallurgiques d'Automne of the Société Française de Métallurgie will be held in Paris during October 19–24. The subject is "Les Gaz dans les Métaux". Further information can be obtained from the Société Française de Métallurgie, 25 Rue de Clichy, Paris 9e.

ERRATUM. Dr. G. Di Sabato writes: "In my communication entitled 'Effect of Reduced Diphosphopyridine Nucleotide on the Swelling of Isolated Mitochondria', published in *Nature* for April 4, p. 997, column 2, 'sucrose 690 μmoles' in line 6 should be 'sucrose 1,200 μmoles', and '180 μmoles' in line 8 should be '18 μmoles' ".

THE GRADUATE SCHOOL IN MATHEMATICAL PHYSICS AT BIRMINGHAM

IN 1956, a Graduate School in Mathematical Physics, leading to a diploma, was instituted in the Department of Mathematical Physics of the University of Birmingham. It had been noticed that students who graduated in the honours school of mathematical physics in the Department seemed well equipped, and considerably in demand, for work involving the applications of mathematics to physical problems in industry, government laboratories, etc., because of the training they received in the principles of physics, and particularly in the techniques of translating physical problems into mathematical terms, and of interpreting the solutions from a physical point of view.

Entry to the honours course at Birmingham is restricted to students of high ability, who must have the appropriate background in their school training, since the three-year course makes fairly heavy demands on the students. It seemed likely therefore that a one-year postgraduate course would be of advantage to students who had taken a degree in mathematics, because they could not—or did not choose to—enter the mathematical physics course, or who graduated from universities at which such a course was not available.

The three years of operation of the Graduate School have provided sufficient experience to judge that it can serve the purpose for which it was intended, and that it imparts to the students knowledge and experience which serves them well in their later work. The course extends over one academic year (October to July) and is normally intended for honours graduates in mathematics with subsidiary physics. In some cases it proved possible to fit in students with somewhat different qualifications. Lecture courses attended by the students include a course in methods of mathematical physics (given so far by Dr. J. G. Valatin, who is in general charge of the Graduate School), which forms the central theme of their introduction to the outlook of a mathematical physicist. In addition, students normally take selected parts of the lecture courses for honours physicists, and those parts of the final-year course for mathematical physicists (electromagnetic theory, hydrodynamics, quantum mechanics) which they have not previously covered, and which suit their particular needs. Other options include mathematical statistics, numerical methods, elasticity theory, statistical mechanics, and usually at least one course in one of the applied science departments. All students attend a weekly seminar arranged specially for the Graduate School in which they contribute themselves, and otherwise hear talks by members of the research group in mathematical physics and others. It has proved possible to arrange for each individual student a combination of courses which suits his particular interests and knowledge.

Although many of these courses are given for other purposes, students find it easy to synthesize their work and to build them into a common foundation of understanding.

The number of students in the course has remained small in the first three years, and is likely to continue small until the existence and purpose of the course become more widely known. It is therefore premature to give any statistics of the subsequent occupations of students who have obtained the diploma. These included work in industry and government laboratories as well as academic research. (One student took up postgraduate work in the Mathematical Physics Department at Birmingham, and two joined an applied science department in the University.)

The development of the Graduate School was greatly aided by the award of advanced course studentships of the Department of Scientific and Industrial Research, and in some cases by grants from the University of Birmingham.

R. E. Peierls

WATER-RESOURCES AND WATER-USE SURVEY

THE study of the use and conservation of water resources is a relatively new geophysical science and one that impinges closely on other sciences such as meteorology and climatology, geology and geomorphology, agriculture, economic geography, demography, etc. The importance in the modern world of economic and land-use planning, particularly with reference to so precious a raw material as water, involves the collection of a vast and varied amount of data and information relevant to the assessment of water resources, on not only a national but also an international basis. Two papers*, published by the World Meteorological Organization, are useful statements in this important field, particularly in view of the varying scientific standards of recording and observation that are available and possible in different world regions.

M. A. Kohler summarizes briefly the types of hydrological data, the network density of observations required, and network planning, and the techniques for estimating hydrological data that can be used. Attention is directed to the impracticability of devising a universally standardized procedure and a scheme is put forward for the creation of a minimum cover of permanent full, partial, and temporary observational stations.

The second, longer, technical paper is more closely concerned with techniques for the surveying of surface

* World Meteorological Organization. Technical Note No. 25: Design of Hydrological Networks. Prepared by Max A. Kohler. Technical Note No. 26: Techniques for Surveying Surface-Water Resources. Prepared by Prof. Ray K. Linsley. Pp. v+16+xl+41. (WHI-No. 82.TP.32.) (Geneva: Secretariat of the World Health Organization, 1958.) 4 Swiss francs.

water resources in a region, and providing estimates of usable water supply. Attention is given to methods which are adapted for use in the absence of adequate hydrological data and to simple techniques of observing hydrological phenomena which may provide useful data with least cost in time and money. Despite the importance of ground-water circulation in all regions—and especially in arid regions—the survey is limited to the discussion of techniques with regard to surface resources. These are a guide to the estimation of requisite rates of replenishment of ground water that are necessary for the effective use of the latter over a period of time. The main topics discussed are the hydrological balance, precipitation, evapotranspiration and its measurement, stream-flow, sediment transport and water supply, and a summary direction for procedure in the matter of water-resource surveys.

The special problems and peculiar needs of a densely populated and highly industrialized country such as Great Britain are summarized in an interesting discussion on a water-use survey opened by Prof. W. G. V. Balchin (under the chairmanship of Prof. Dudley Stamp), with contributions from experts representing a very wide range of technical interests in this important field (*Geog. J.*, **124**, 476; 1958). Prof. Balchin directs attention to the dramatic increases in water consumption in Britain during the past century, culminating in an increase of 50 per cent in England and Wales and 41 per cent in Scotland during the short period 1938–56. The water storage capacity in the same time has increased by only 46 per cent and 31 per cent, respectively. The area where the consumption is greatest is the area where population is densest and the rainfall least, and where the local resources are already fully employed—that is, in lowland Britain and particularly in the great urban and industrial complexes.

These papers are a salutary reminder, through the many facets to the problem of water conservation that they reveal, of our ultimate dependence on water resources and our need to avoid over-exploitation of a raw material that, in Great Britain at least, people assume all too readily is in abundant supply, and for which in many others the supply is already precarious.

ALICE GARNETT

CARNEGIE TRUST FOR THE UNIVERSITIES OF SCOTLAND

THE fifty-seventh annual report of the Executive Committee of the Carnegie Trust for the Universities of Scotland covers the year 1957–58 (pp. iv + 74. Edinburgh: Carnegie Trust for the Universities of Scotland, 1959) and includes the financial accounts for the year ended September 30, 1958. A major preoccupation of the Executive Committee during the year was the formulation of a policy to implement its new powers of investment. During the year there were on the books five senior research scholars, thirty-six research scholars in their second or third year, and twenty-five in their first year. For 1958–59 the value of the senior scholarship has been increased to £500 (with an additional £100 for expenses), while scholars at Oxford, Cambridge and London will receive £450; scholars living away from home, attending a Scottish or an English provincial university, £400; and scholars living at home and attending a Scottish university, £350. A grant of £4,000 a year for five years from the end of 1958 was made to the Scottish Dictionaries Joint Council, subject to some conditions with regard to progress. Ten of the research grants awarded during the year were for expenses involved in illustrating the published results of research and five grants were made to authors as a subvention towards the cost of publishing their books.

Four grants are particularly mentioned. The Trust has provided a special heavy-duty vehicle and a 'Folboat' with outboard motor and a grant for running expenses to assist Prof. J. H. Burnett and Dr. D. H. N. Spence, of the University of St. Andrews, in preparing a comprehensive account of the aquatic vegetation of Scotland, a research which involves crossing many moorland roads to examine distant mountain lochs. A grant of £2,500 was made to Prof. R. H. Matthew, of the University of Edinburgh, for a study by a research team correlating the problems of the design of basic dwelling units, lay-out, siting and services with social requirements, with specific reference to contrasting types of social grouping and including a cost study. Another grant was to the University of Glasgow North Rona Expedition, which spent about a month on North Rona and Sula Sgeir, paying particular attention to marine biology. Some very rare species of algae were found and a special census was made of Leech's petrel. A second successful expedition, assisted by a grant from the Trust, was one from the University of Aberdeen, led by Prof. A. C. O'Dell, to St. Ninian's Isle, Shetland, in June–July 1958, in which a most important collection of silver ornaments was uncovered.

Of the ten grants for travel and maintenance made to members of university staffs engaged in research, three were to members of a faculty of medicine, four in science and three in arts. Among these may be mentioned those to Dr. W. I. Card to enable him to visit centres in the United States and Canada, where work of interest and importance in gastro-enterology is proceeding; to Mr. Alastair Fraser, to work in Copenhagen in the laboratories of Prof. M. Thomsen and Dr. E. Thomsen, leading authorities on insect endocrinology, and later in Liège, Brussels and Paris; to Dr. C. H. Gimingham to enable him to follow up in Scandinavia his investigations in Scottish heaths, aimed at gaining a comprehensive picture of the ecology of heather, including its reactions to grazing and burning and influences of soil climate and at utilizing this information in an investigation of the ways in which heath lands have originated and are maintained; to Dr. Elizabeth D. Fraser, to enable her to test in America some of her hypotheses regarding perceptual constancy as a function of personality and learning and the effect of metabolic disturbance; and to Dr. P. H. Tuft, to discuss his experimental techniques in embryology in the United States.

THE SCHOOL HEALTH SERVICE IN BRITAIN

THE School Health Service is fifty years old. In the half-century of its existence there have been remarkable changes in the health of school children, and in the pattern of illnesses affecting them. Both boys and girls to-day are taller and heavier, better clad, better shod and cleaner. They reach physical maturity earlier and may expect to live twenty years longer. In sharp contrast to the conditions of malnutrition found only too commonly 50 years ago, medical attention is now being drawn towards an increasing number of school children who are too fat.

The annual report* of the Chief Medical Officer presents these facts and discloses among other vital statistics that the killing and crippling diseases prevalent at the turn of the century—tuberculosis, rickets and rheumatism—have been practically eliminated. The remaining causes of crippling and other forms of handicap are now mainly congenital or hereditary in origin. Accidents still kill twice as many children as die from disease, and road accidents are responsible for half the deaths recorded. Boys are more liable to death on the road than girls; leaving school in the afternoon is one of the most risky periods of the day.

Nearly 250,000 children were found to have verminous heads in 1957. This is about 4 per cent of the total school population. "This condition is preventable and there is seldom any excuse for it", says the report. "It is essentially a family problem, children being infested and re-infested by adults". The current question of smoking and its relation to lung cancer provides "a striking example of the need for boys and girls, while still at school, to be taught something about healthy living—by example, perhaps, more than by precept. In spite of all that has been said and written about the close connexion between the two, many children still smoke cigarettes". A recent inquiry carried out at a mixed secondary modern school in the Isle of Wight disclosed that about a third of the boys and 15 per cent of the girls were regular smokers.

The incidence of dental decay has increased in the past few years among school children, and is due "probably to the greater amount of sweets and confectionery eaten since the end of sweet rationing". Fluoridation of water supplies probably offers the best hope of reducing this incidence, "but large scale benefits from this measure can hardly be expected for several years".

One consequence of the changing pattern of ill-health in childhood is that school health service staffs now devote more attention to children who are emotionally disturbed, or who suffer from some handicap which threatens to have a retarding effect on school progress from a psychological cause.

There is also the challenge of the delinquent school child which cannot be ignored by the school health service. The number of children charged before the juvenile courts has risen from 13,000 in 1913 to 38,000 in 1956. It is right, says the report, that the school health service should concern itself with the problem and co-operate with the other agencies involved. In 1957 more than six and a half million children attending about 30,000 maintained and assisted schools were covered by the service. More than two million have a periodical inspection during the year.

* The Health of the School Child: Fifty Years of the School Health Service. (Report of the Chief Medical Officer of the Ministry of Education for the years 1956 and 1957.) Pp. i+220+12 plates. (London: H.M. Stationery Office, 1958.) 10*s.* 6*d.* net.

INCENTIVES IN THE BUILDING INDUSTRY

A RECENT Building Research Station report* on incentives in the building industry shows that bonus schemes have an important contribution to make to building efficiency. The maximum benefit can only be derived, however, if they are integrated into a rational pattern of management. The report enumerates principles on which an incentive scheme should be based as well as the method of operation if it is to be successful.

Operation targets, coupled with a recording system giving operation costs, should be used whenever possible. The operations should be the visual stages of work, of about one week's duration, and continuous jobs with no hold-ups for other trades.

The scheme should be designed to suit individual needs and local conditions. This calls for flexibility in targets to suit the local productivity of labour and the distribution of bonus payments. The operatives on each site should decide the method of sharing within the bonus group or gang. It is necessary to safeguard the quality of work by making site staff independent of production bonus and improving site supervision of quality.

A number of conclusions were reached about the methods of operation of an incentive scheme. Accurate and well-balanced targets should be maintained by the systematic use of cost information from all the firm's sites and by close consultation with its site staff. The incentive effect of a scheme is greatest when it is given a central position in the organization of the firm, especially if administered by the contract management side. There should be close liaison between estimating and the fixing of target bonus-rates. The principles of the scheme should be kept simple and explained to the operatives so that they can calculate their own bonuses. The bonus units are small gangs.

* Department of Scientific and Industrial Research: Building Research Station. National Building Studies Special Report No. 28: Incentives in the Building Industry. By Alison Entwistle and W. J. Reiners. Pp. iv+43. (London: H.M. Stationery Office, 1958.) 3*s.* net.

The bonus paid should be the actual amount of bonus earned ; there should be no limit to the amount of bonus that can be earned ; the bonus should be paid weekly and as soon as possible after the completion of the operation. The scheme should cover, so far as possible, all the work on the site. Good labour relations on the site are an aid to productivity and should be encouraged by presenting the targets to the operatives for agreement before work starts and a recognized channel for complaint should be established. Provision should be made to allow targets to be modified on a particular site if adequate reason is established. Disputes or complaints should be dealt with speedily and in consultation with the site staff.

SURFACE OF THE OCEAN AS A SOURCE OF AIR-BORNE NITROGENOUS MATERIAL AND OTHER PLANT NUTRIENTS

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In an earlier communication[1] the occurrence of organic nitrogen in New Zealand snows was reported, and it was suggested that this might represent a contribution to the nitrogen economy of New Zealand soils. This article presents further results on the subject and points to the most probable origin of this air-borne nitrogenous material.

Samples of snow have been collected from above the vegetation line to avoid possibility of contamination by plant or animal debris. This was done in preference to the more conventional rain-water sampling which is open to large contamination errors. The analyses[2] of these samples are shown in Table 1.

Since the samples described here were freshly collected snow from regions where no plants or animals exist, contamination from these sources should be negligible. No insoluble inorganic material was visible in the samples, so that cyclic terrestrial dust could not contribute appreciably to the nitrogen found in the samples. This is to some extent further supported by the lack of nitrate in the samples. The samples were collected in early and mid-winter when the pollen contribution would be negligible. It seems that precipitation, at least in New Zealand, does in fact contain appreciable quantities of bound nitrogen which does not arise from contamination.

Origin of Organic Nitrogen in Snow

The problem immediately arises as to the origin of this material. When one considers the geographical position of New Zealand, situated as it is in a westerly air stream and surrounded by thousands of miles of ocean, it is difficult to avoid the conclusion that the source is the ocean itself. The ocean, however, contains only about 0·008 p.p.m. of albuminoid nitrogen. Further, if the snow is analysed in more detail, one sees that it is not merely diluted sea water but that its potassium/sodium ratio is an order of magnitude greater than that of sea water.

In order to explain these facts, it is necessary to postulate that the upper, very thin layer of the ocean has a different composition from that of the rest of the ocean ; in particular, that it is enriched in potassium, ammonium, organic material and organic nitrogen, and probably various other materials. It is suggested that most debris (for example, from plankton) is either heavier or lighter than sea water and, if heavier, sinks to form sediments, and if lighter, rises to form this layer, which therefore contains micro-organisms and other plankton in a state of partial decomposition and would be expected to be rich in organic matter. It would also be expected to have an increased potassium/sodium ratio, since many marine organisms concentrate potassium. It is known[3] that when a bubble of gas passes through a liquid-gas interface, the act of the bubble bursting throws up a small droplet from the surface of the liquid into the gas phase. This must occur in the phenomenon known as 'white caps' (that is, when a wave breaks). The haze produced by these particles is quite noticeable on a fine day when a heavy surf is running. Thus, the composition of these droplets reflects that of the surface layer and not that of the bulk ocean.

It is reasonable to assume from the foam produced in rough ocean that some surface-active material is present on the surface of the ocean. During strong onshore winds, large quantities of foam accumulate on the shores of New Zealand which provides an opportunity to sample directly the surface layer of the ocean. A sample of ocean foam was collected on the west coast just north of Wellington. The foam was broken with a silicone anti-foaming agent and allowed to stand. It proved to be 25 per cent solid matter. On microscopic examination, this material was found to be particularly rich in bacteria and also had large quantities of diatoms and fragments of phyto- and zoo-plankton. The chemical analysis of this material is shown in Table 1. It is interesting to note the high nitrogen content and that the potassium/sodium ratio is higher than that in sea water.

The relationship between the surface layer of the ocean and snow water is most clearly seen when one plots the 'excess potassium concentration' against the 'albuminoid nitrogen concentration'. This is done in Fig. 1. The excess potassium concentration is obtained by subtracting from the potassium concentration 1/27 of the sodium concentration, that is, that amount of potassium which would be associated with the sodium in sea water. We see that the results from the ocean foam and the snow water samples lie on a straight line which can be extrapolated back to give the albuminoid nitrogen concentration in sea water. This is strong evidence in favour of their common origin, and supports the hypothesis that the

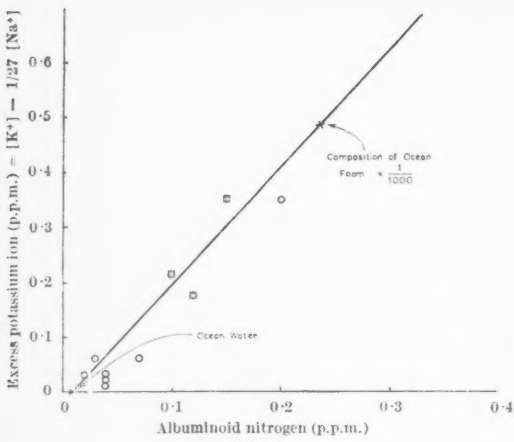

Fig. 1

nitrogen in snow originates in the surface layer of the ocean.

The above evidence suggests a new path in the nitrogen cycle, at least for New Zealand, and probably for other areas with rough oceans to their windward. Elementary nitrogen dissolves in the sea and is fixed by marine micro-organisms. These eventually rise to the surface and are caught in the surface layer, where some are partly decomposed by other micro-organisms into ammonia and other products. The micro-organisms and their decomposition products are carried into the air by a bursting air bubble in a 'white cap'. In the air the droplet would lose its moisture and a part of its ammonia, and as a small and light particle be carried far inland to settle out or to serve the very useful function of seeding rain clouds. On reaching the ground this material would contribute to the soil, nitrogen and potassium and possibly other materials necessary for plant growth. From the lack of NO_2' and NO_3' in the samples, this path in the nitrogen cycle might be considered more important than the conventional fixation of atmosphere nitrogen by atmospheric electrical discharges, at least for the areas covered by the sampling. This then might represent a net transfer of bound nitrogen from the ocean to the land.

Table 1

Description of sample	Nitrogen content of snow samples (ref. 3)					Na^+ (p.p.m.)	K^+ (p.p.m.)	Corrected $K^+ = K^+ - 1/27\ Na^+$ (p.p.m.)	K^+/Na^+
	NO_3' (p.p.m.)	NO_2' (p.p.m.)	NH_4^+ (p.p.m.)	Organic (albuminoid) nitrogen (p.p.m.)	Sum (p.p.m.)				
(1) Snow collected April 26, 1958, 6,000 ft. (tree line 4,000 ft.) during snowstorm on Mt. Ruapehu (100 miles from sea). Wind W.S.W.	0	trace < 0·002	0·08	0·15	0·23	1·38	0·4	0·35	0·29
(2) Freshly fallen snow collected April 26, 1958, at 5,300 ft. on Mt. Ruapehu	0	trace < 0·002	0·03	0·2	0·23	1·35	0·4	0·35	0·296
(3) Snow collected May 3, 1958, at 6,000 ft. (tree line 4,000 ft.) on Mt. Egmont (20 miles from sea)	0	0	0·03	0·1	0·13	0·68	0·24	0·215	0·354
(3a) Snow taken under (3)—previous snowfall ?	0	trace < 0·002	0·05	0·03	0·08	1·02	0·1	0·06	0·098
(4) Snow collected April 27, 1958, at 7,000 ft. (tree line 3,000 ft.) on Tasman Glacier (25 miles from sea)			0·1	0·12	0·22	0·20	0·18	0·175	0·90
(5) Rain collected in Wellington in southerly storm on April 26, 1958. Distance up wind to open sea 10 miles, altitude 10 ft.	0	0·002	0·27	0·2	0·47				
(6) Snow collected July 20, 1958, at 5,750 ft. (tree line 4,000 ft.) during a snowfall on Mt. Ruapehu) (100 miles from sea)	0	0	0·2	0·04	0·24	0·15	0·01	0·01	0·067
(7) Snow collected July 21, 1958, at 6,575 ft. Same fall as in (6)	0	0	0·33	0·07	0·40	0·16	0·06	0·06	0·375
(8) Snow collected July 21, 1958, at 8,070 ft. Same fall as in (6)	0	0	0·2	0·02	0·22	0·11	0·03	0·03	0·273
(9) Snow collected August 2, 1958, at 6,000 ft. during snowstorm on Mt. Ruapehu	0	0·001	0·02	0·09	0·11				
(10) Fresh snow collected August 22, 1958, at 5,000 ft. at Temple Basin, Arthur's Pass (tree line 3,000 ft., 30 miles from sea)	0	0·002	0·01	0·04	0·05	0·04	0·02	0·02	0·50
(11) Fresh snow collected September 10, 1958, at 5,700 ft. on Mt. Ruapehu	0	0	0·01	0·04	0·05	0·65	0·05	0·03	0·077
(12) Ocean foam collected on rocky coast north of Wellington during strong on-shore westerly wind					235	12,000	930	485	0·078
(13) Typical ocean water		0	0·004	0·008		11,000	410	0	0·037

Application of Hypothesis to Other Problems

Origin of Ammonia in Air and Rain. The presence of ammonia in air and rain has been known for many years. Its origin, however, has been in doubt[1]. The ocean seemed to be the most likely source except that calculations based on the equilibrium constant between air and water, together with the concentration of ammonia in the sea, rule out this possibility, even though in New Zealand's case there seems to be no other. The hypothesis presented in this article would imply that the ammonia is coming, not from the bulk ocean, but from the surface layer and from the evaporation of the small droplets which are thrown up into the air by the bursting bubbles. Variable quantities of ammonia will be lost by these droplets to the air, depending on their *p*H and composition. Indeed, the results in Table 1 seem to show that the higher the albuminoid fraction the lower the ammonia retained in the droplet and vice versa. This might be due to the buffering effect of the basic nitrogenous material.

Potassium/sodium ratio in rain water. It is a well-known fact that the potassium/sodium ratio in rain water is often larger by a factor of 10 than that in the sea—the obvious source. This can be readily explained in terms of the above hypothesis, since the rain would derive its salts from the surface layer of the ocean, which in turn is rich in marine organisms, many of which are known to have much higher potassium/sodium ratios than the 1/27 of sea water.

Charge discrepancy in rain water. The total sums of all the charges carried by the anions and cations in rain water sometimes do not balance. This can be explained by the presence of organic compounds balancing the excess charge.

Ocean foam. The origin of the foaming agent in the sea is not certain, but it is possible that it is produced by the bacteria themselves and serves to trap their food and also to aid in their aeration.

Many of the sheep stations on the New Zealand coasts and islands carry more sheep than might from other considerations be expected, and without aerial top-dressing[5]. This effect decreases with distance from the sea, and applies only to areas lying within 10 miles of the coast. Could this be the result of wind-blown foam carrying plant nutrients to these coastal areas ?

Bacterial action of the sea. There is a discrepancy between the supposed bacterial action in the sea and the very few bacteria found therein[6]. Is it possible that a large fraction of these biological processes takes place on the surface layer of the ocean, and that these are not effectively sampled by the normal methods which sample the bulk ocean rather than the surface ?

Life in the inter-tidal zone. The occurrence of large quantities of organic matter and nutrients in the surface layer of the sea might provide the food supply for the large amount of life that exists in and near the inter-tidal zone.

I wish to thank Mr. H. J. Wood of the Dominion Laboratory, Wellington, for the nitrogen analyses, and Mr. A. J. Heine and Mr. G. Pallo, Department of Scientific and Industrial Research, for collecting samples.

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COMBINED EFFECTS OF CORTISONE AND INSULIN ON DEVELOPING CHICKEN EMBRYOS

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THE injection of insulin into the yolk sac of chicken eggs after an incubation period of 4–8 days is responsible for the occurrence of a shortening of the long bones of the legs (micromelia) and of abnormalities of the beak; the mean body-weight of such embryos is somewhat reduced. The severity of these symptoms varies with the amount of injected insulin[1]. The principal effect of cortisone, injected during the same developmental stages, is a marked dwarfing of the embryos, but without the production of skeletal malformations[2]. When both insulin and a potent adrenal cortex extract (but of unknown cortisone concentration) were injected after 5 days of incubation, it was found that the incidence of insulin-specific skeletal abnormalities was significantly greater than after the injection of insulin alone[3,4]. In similar experiments, but done after 8 days of incubation and using cortisone in combination with insulin, Lunardo and de Bastiani did not find a potentiation of the insulin effect[5]. It seemed of interest, therefore, to determine if differences of developmental stage are responsible for dissimilarities in the effects produced by simultaneous treatment with cortisone and insulin or if the discrepancies between our earlier observations and those of Lunardo and de Bastiani have other causes.

For our present tests we used eggs of White Leghorn fowls. Sterile solutions of cortisone (cortone acetate, Merck) and of insulin (Lilly) were injected into the yolk sac after 4 or 8 days incubation. The details of our experiments are presented in Tables 1 and 2. In recording skeletal abnormalities, all degrees of shortening of the legs were pooled; similarly, all types of beak defects were grouped together. The incidence of other skeletal abnormalities was very small and was not separately recorded; these defects occurred with about equal frequency in all groups and, since there was no reason for believing that they owed their origin to our experimental procedures, they were added to the 'normal' groups.

Untreated eggs served as controls of the various experimental groups. For the test reported in Table 1 we had 37 fertile and untreated eggs; 33 of these

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Table 1. Experiments in which Cortisone, Insulin, or both Cortisone and Insulin were injected into the Yolk Sac of White Leghorn Eggs after 96 hr. of Incubation and at the Dosages given Below

	Cortisone			Insulin			Insulin and cortisone		
Experiment	1	2	3	1	2	3	1	2	3
Insulin units/egg	—	—	—	3·2	3·2	4	3·2	3·2	4
Cortisone, mgm./egg	1·25	1·25	1	—	—	—	1·25	1·25	1
Number treated	26	27	30	26	27	30	54	48	90
Survival to eighteenth day, per cent	57·7	81·5	76·6	84·6	63·0	73·0	37·1	47·8	35·5
Number survivors	16	22	23	22	17	22	20	23	32
Body-weight, gm.	14·26 ± 0·98	13·73 ± 0·86	13·90 ± 0·83	19·59 ± 0·81	15·15 ± 0·79	13·37 ± 0·73	12·70 ± 0·87	8·71 ± 0·50	10·14 ± 0·67
Normal, per cent	100	100	100	87·0	64·7	36·4	75·0	65·2	18·8
Short legs, per cent	0	0	0	13·0	35·3	54·5	25·0	34·8	59·4
Abnormal beak, per cent	0	0	0	13·0	11·8	27·3	5·0	4·4	25·0

In those groups in which both hormones were injected the ratio of cortisone to insulin amounted to 0·39 in experiments 1 and 2 and to 0·25 in experiment 3. All living embryos were weighed and examined after 18 days of incubation. Incidence of 'normal' embryos and of abnormalities of the legs or beak in percentage of survivors to eighteenth day. Standard errors of body-weight.

Table 2. Experiments in which Cortisone, Insulin, or both Cortisone and Insulin were injected into the Yolk Sac of White Leghorn Eggs after Eight Days of Incubation and at the Dosages given Below

	Cortisone			Insulin			Insulin and cortisone		
Experiment	1	2	3	1	2	3	1	2	3
Insulin units/egg	—	—	—	3·2	3·2	4	3·2	3·2	4
Cortisone, mgm./egg	1·5	1·5	1	—	—	—	1·5	1·5	1
Number treated	40	10	55	40	20	55	70	40	80
Survival to eighteenth day, per cent	67·5	90·0	89·1	80·0	90·0	80·0	68·5	87·5	73·7
Number survivors	27	9	49	32	18	44	48	35	59
Body-weight, gm.	11·87 ± 0·52	13·92 ± 0·65	16·56 ± 0·45	18·20 ± 0·47	16·95 ± 0·50	17·75 ± 0·49	13·53 ± 0·42	13·24 ± 0·42	14·85 ± 0·56
Normal, per cent	100	100	100	50·0	27·8	34·1	81·3	71·4	49·2
Short legs, per cent	0	0	0	50·0	72·2	65·9	17·9	28·6	50·8
Abnormal beak, per cent	0	0	0	0	5·6	0	5·1	0	18·6

In those groups in which both hormones were injected the ratio of cortisone to insulin amounted to 0·47 in experiments 1 and 2, and to 0·25 in experiment 3. All living embryos were weighed and examined after 18 days of incubation. Incidence of 'normal' embryos and of abnormalities of the legs or beak in percentage of survivors to eighteenth day. Standard errors of body-weight.

(89·2 per cent) survived to 18 days and the embryos at that age had a mean body-weight of 20·95 ± 0·53 gm. As controls for the experiments of Table 2 we had 26 fertile and untreated eggs; 22 of the embryos (84·6 per cent) lived at 18 days and had a mean weight of 19·37 ± 0·56 gm. None of these 55 embryos showed skeletal malformations of the kind with which the present discussion is concerned.

Effects on survival. Among embryos treated at 4 days with both insulin and cortisone the mortality was consistently higher than it was in the groups treated with either hormone alone. In fact, the toxicities of insulin and cortisone were nearly additive, and most of the group differences in mortality (or survival) are highly significant. At 8 days, on the other hand, survival after the combined treatment did not differ significantly from that occurring after injection of either insulin or cortisone. Comparing the experiments at 4 and 8 days, and taking into account such dissimilarities of dosage as existed, no consistent or significant changes appear to have occurred in the toxicity of either cortisone or insulin. Highly significant differences are found, however, between the combined treatments at the two developmental stages. In experiments 1 and 2, in which the ratio of cortisone to insulin was higher at 8 days than at 4 days (0·47 vs. 0·39), the differences amounted to 31·4 ± 8·65 and 39·7 ± 8·90 per cent respectively; in the two third groups, with identical ratios (0·25), the difference in survival was 38·2 ± 7·04 per cent.

Effects on body-weight. Following treatment after 4 days of incubation, the injection of both hormones led in all three groups to a greater retardation of growth than that produced by either insulin or cortisone. In groups 2 and 3, the mean body-weights, after combined treatment, fell significantly below those of the groups treated with either cortisone or insulin alone. At 8 days the combined treatment led to a significantly lower body-weight in comparison with the insulin-treated embryos; but the differences between the groups that had been injected with both hormones and those that had received only injections of cortisone were neither consistent nor statistically significant. A comparison of the treatments at the two development stages reveals some interesting differences. Against the lowest amount of cortisone which we used (1 mgm./egg) the 8-day embryos had become significantly more resistant than those treated at 4 days, their mean body-weight being 2·66 ± 0·94 gm. higher; the results of experiments 1 and 2 are not directly comparable because of dosage differences. The injection of 3·2 units of insulin at 4 and 8 days did not produce significant dissimilarities in body-weight, but after 4 units the 8-day embryos were less retarded (difference: 4·38 ± 0·88 gm.). The results for combined injection of insulin and cortisone in experiments 1 and 2, because of dosage differences, do not allow a comparison between 4 and 8 days, but the results of tests with 1 mgm. cortisone and 4 units insulin (experiments 3) demonstrate that growth of the embryos treated at 8 days was much less retarded than it was following injection at 4 days (difference: 4·71 ± 0·27 gm.).

Teratogenic effects. As one would expect, the incidence of malformations increased with dosage in the groups treated with insulin alone and in those treated with insulin and cortisone. This was true at both developmental stages. A comparison of the effects of insulin treatment with the results of the combined injection of insulin and cortisone shows no significant differences in the incidence of skeletal defects at the 4-day stage, except for a slight but consistent trend of the abnormalities to be more extreme in the groups treated with both hormones: in the groups tested at 8 days, on the other hand, the combined treatment was less teratogenic than injection of insulin alone. For the pooled data of experiments 1 and 2 (with identical ratios of cortisone

to insulin) these differences were highly significant ($\chi^2 = 16{\cdot}82$, $P < 0{\cdot}001$), and the same is true for the combination of probabilities for experiments 1, 2 and 3 ($\chi^2 = 30{\cdot}31$, d.f. $= 6$, $P < 0{\cdot}001$).

Our results demonstrate clearly that between 4 and 8 days of incubation a change occurs in the reactions of the developing chicken embryo to combined treatment with insulin and cortisone. The older embryos survive better, show less retardation of growth and a lower incidence of skeletal malformations. These differences in response presumably are a reflexion of the homœostatic forces which the incipient functioning of the endocrine systems brings into play. Our observations, secondly, confirm the report by Lunardo and de Bastiani that cortisone does *not* potentiate the teratogenic action of insulin. Since our earlier experiments with an extract of adrenal cortex produced very striking potentiation, it must be concluded that this was due not to 17-hydroxy-11-dehydrocorticosterone (cortisone) but to one or more of the other corticosteroids contained in the extract. This we hope to verify in future experiments.

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MATERNAL CONTROL OF OVARIOLE NUMBER IN THE PROGENY OF THE MIGRATORY LOCUST

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AN integral part of the phase theory of locust transformations is the cumulative transmission of phase characters from one generation to another, so that fully *gregaria* or *solitaria* types can be obtained only when crowding or isolation of the locusts is maintained for several generations. The transmission of phase status to the progeny is held to occur through the accumulation of extra-chromosomal materials in the egg[1]. Early criticisms, understandably in view of the specific status given to the phases previously, held that they were genetically distinct but formed hybrids.

The weight of field and laboratory evidence has now accumulated to the point where the essentially non-genic nature of this inheritance is taken for granted, although the capacity of expressing it depends patently on the genotype concerned. This striking illustration of what Thoday[2] has called phenotypic flexibility has received scant notice save for some remarks of Kennedy[3,4].

Hunter-Jones[5] has shown that crowded female desert locusts, reproducing parthenogenetically, produce offspring which in colour and weight are typically *gregaria* whereas the same stock of females, when isolated, give *solitaria*-type larvæ. Our experiments show that telotykous parthenogenesis also occurs with the migratory locust, *Locusta migratoria migratorioides* R. and F. Moreover, the number of ovarioles in female offspring of isolated unfertilized females ranges from 95 to 105, whereas hatchlings from crowded mothers carry only 75–85 ovarioles. We may look to the female reproductive system for some of the clues to this problem.

There seem, in fact, to be two physiological processes at work; one of these operates through the vitellus of the egg, the reduction of which by ligaturing after blastokinesis produces larvæ which have the *solitaria* coloration (pale green) from crowded stocks of the migratory locust, the normal larvæ of which would be black and heavy[6]. Generally, weight and colour are closely associated[5], both with one another and with the subsequent rate of development and number of moults of some species of locust[7,8]. The number of ovarioles borne by these ligatured larvæ is, on the contrary, typical of *gregaria* populations. Thus the inheritance of this important phase character[9] seems to be independent of the amount of vitellus remaining in the egg. This distinction, however, may prove to be one of the timing of the processes of ovary formation and larval coloration; in *Melanoplus* and *Drosophila* at least, ovariole number seems to be determined prior to or during blastokinesis[10,11].

Table 1. MEAN REGRESSIONS OF OVARIOLE NUMBER ON HATCHLING WEIGHT OF THE MIGRATORY LOCUST, REPRESENTING THE INCREASE OF POTENTIAL REPRODUCTIVE CAPACITY FOR A SACRIFICE OF 1-MGM. WEIGHT AT BIRTH
(Standard errors of regression coefficients about 0·25 throughout)

Generation	Regression and subsequent rearing density			
I	Crowded (Stock from Musée d'Histoire Naturelle Paris)			
II	Crowded			
III	Crowded			
IV	Crowded		Isolated	
V	Crowded 1·27		Isolated 2·85	
VI	Crowded 1·90	Isolated 1·75		
VII	Crowded 1·27	Isolated 0·63		

There is in general an inverse relation between weight at hatching and the number of ovarioles in locust larvæ[9,12]. The interlocking of these two characters depends on the consistency with which the earlier generations have been kept crowded or isolated. To the extent that we may think of this relationship as a measure of the interchangeability

of reproductive potential (number of ovarioles) and larval mobility (weight of occluded food reserves) the changes of its magnitude are of interest whatever the mechanism of inheritance. Table 1 shows the mean regressions of ovariole number on hatchling weight for comparisons made among larvæ issuing from one and the same egg-pod. Each pod contains up to 100 eggs derived from a single ovarial cycle in the female. Comparisons across egg-pods or across the progeny from different females are swamped by extraneous sources of variation which themselves depend on the consistency of ancestral density. Generation VI (crowded grand-parents; isolated parents) were 67 times as variable as generation VII, for which isolation was the parental and grandparental regime. Yet even generation VII was 9 times as variable, as a whole, than were contrasts made within egg-pods as are those in Table 1: these varied in precision scarcely at all throughout the experiment.

Crowding leads to a cumulative gain in weight at hatching for a given sacrifice of reproductive potential, and since this sacrifice has evidently not entirely been made good even three generations after crowding was ended we have the longest reach, of any yet recorded, of a density-dependent effect being transmitted to the descendants of the crowded generation. Similar inheritance has, however, been demonstrated in the shorter run with other characters[5,7]. In a general and less-precise way this inverse relation may be extended to fully *solitaria* and *gregaria* females; the progeny of the *gregaria* are fewer and heavier, and have fewer ovarioles compared with the progeny of *solitaria*; nevertheless, both phases produce about 1 gm. of living material in each egg-pod.

Setting Limits to Selective Action during the Egg Stage

Our series of 6,000 preparations of the dissected ovaries of several generations of the migratory locust affords an opportunity to set limits to the action of any selective forces operating during the development of the eggs; for the number of ovarioles in the laying female is the upper limit to the number of her progeny from which the issue of any one egg-pod can have been selected, always excluding the possibility of pre-ovogenetic selection. In particular, the sequence of egg-pods laid by isolated females was studied either when the female was left with the male after copulation for the rest of her life, when the number of ovarioles in her progeny steadily diminished, or when the male was removed after 24 hr. in the cage, to allow copulation to occur, when no such diminution was observed. The influence of the male, once fertilization has been accomplished, is mildly to disturb the female and to induce a modest amount of those inhibitory effects normally associated with crowding. The mean ovariole number of offspring from a female left with one male drops by one ovariole for each of the 15 or so reproductive cycles that the female undergoes. More drastic crowding augments this progressive loss but also shortens the sequence of reproductive cycles so that the net effect is not greatly different.

'Crowding' the females with a single male produces offspring of which the mean number of ovarioles eventually lies outside the range of the phenotypes initially produced by the same mating pair. At most, less than half this cumulative shift can be attributed to selection, and in fact there is no evidence that any of it is so induced. The absence of such a shift, in females from whom the male is removed within a few hours of copulation, excludes any influence of age alone on the mother.

Regulation of Fertility and Fecundity in the Migratory Locust

Implicit in the phase theory of locust outbreaks is some autoregulation of fertility or fecundity according to the population density. Our results provide some idea of the nature of such regulation in the migratory locust; other species seem to differ in important respects, and caution is needed in extending these findings to them.

The influence of crowding operates both within and between generations. The distinction between larval and adult crowding is vital for these comparisons, since changes of density rather than the level of the density seem to elicit the regulatory processes. Crowding during the larval instars almost doubles the number of egg-pods laid by the ensuing adult females, whereas adult crowding inhibits the laying female either from fulfilling her potential delivery of egg-pods or from endowing her female offspring with their appropriate complement of ovarioles. In this way larval and adult crowding act in opposite directions; and may substantially nullify one another during consistent crowding. Yet when the larvæ are crowded and the adults isolated, as occurs with stragglers from gregarious groups, as many as 1,500 eggs may be laid by each female; when the reverse regime is imposed, only about a tenth of this number is to be expected.

However clearly one may recognize that these ideas relate only to a few aspects of a much wider problem, the control of fecundity in the migratory locust may be regarded as a homœostatic mechanism tending to stabilize population density. In every generation we have found a significant negative regression of ovariole number on hatchling weight, which we interpret as a latent ability to exchange larval food reserves for reproductive capacity. When grouped locusts are dispersed, this adjustment is called into play and only fades away when several generations of isolation have failed to restore the population density through an increase in fecundity of the offspring. The last word in these matters often lies with the climate, which can override the locusts' best endeavours at regulation[13].

Generally, it appears that the ability to produce offspring, the average fecundity of which is well outside the phenotypic range of the parents, lies at the heart of the capacity of migratory locusts to cope with rapidly changing environments. An analysis of growth and of moulting polymorphism in the red and desert locusts led us to conclusions in the same vein[8]. A full account of the experiments on which the present conclusions are based is being published[9].

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LETTERS TO THE EDITORS

PHYSIOLOGY

An Exteroceptive Block to Pregnancy in the Mouse

EXPERIMENTS on the effect of certain oral progestogens during early pregnancy, in continuation of previous observations[1] on non-pregnant animals, involved placing a recently mated female receiving oral progestogen with a strange male. In a number of the mice the procedure resulted in failure of pregnancy from the first mating and a new mating within 3–6 days. Control experiments showed that the same effect was produced by dosage with inert material or even without any treatment other than the introduction of a strange male at 24 hr. after mating. 20 out of 49 females behaved in this way, a far greater proportion than could be attributed to the expected incidence of anovular cycles. Only about 8 per cent of young females, as used, return to œstrus within 4–5 days if removed from the male after their first mating, or copulate again at this time if they are left with the male. Moreover, among the suspect females there was a failure of the pseudopregnancy which might have been due to poor stud males. Experiments were therefore undertaken to explore this effect.

Two test situations were devised. Situation *A* was as already mentioned, that is, the recently mated female was paired with a strange partner 24 hr. after copulation with the stud male. Situation *B* was one of proximity without contact, the female being housed in a small cage inside a stock box containing other mice which could climb about the cage but not enter it.

The stud males and all the females were albinos. The test males were either albino or wild-type. Young virgin females were mated in pairs with a stud male; the females were removed from the male when the vaginal plug was found and housed together overnight. 24 hr. later they were presented with the test situation. The females were generally left in the test situation for 7–10 days, and they were then removed to normal mouse boxes. The pregnant females were isolated before parturition, and females which became pseudopregnant or in which the pregnancy had been blocked received a fertility test with a stud male. The few females which proved to be infertile were excluded. Daily vaginal smears were examined.

The results of these investigations are briefly summarized in Table 1.

Table 1. PREGNANCY BLOCK IN THE MOUSE
The females were separated from stud males on finding vaginal plug, and housed together until presented with the test situation 24 hr. later

Test situation	Females having blocked pregnancies	
	Proportion	Per cent
A Housed with:		
Strange normal male (albino)	19/69	28
Strange wild-type male	25/35	71
Castrated male (albino)	13/50	26
Another female (parous or ovariectomized)	0/48	—
Original stud male	0/32	—
B. Proximity without contact: that is, in cage inside stock box containing:		
Albino males	8/32	25
Wild-type males	52/68	76
Females	0/49	—

Pregnancy was blocked and implantation inhibited in nearly 30 per cent of females by the introduction of a strange male within 24 hr. of coitus; it was so blocked even by the presence of a castrated male. Pregnancy was not affected by the return of the female to her original stud male or by the presence of a strange female, whether parous or ovariectomized. Contact between the sexes was not necessary for this effect. Pregnancy was also blocked when the female was caged inside the male stock box. Among parous females, pregnancy was less readily blocked than among non-parous by contact with a strange male, but apparently broke down as easily when the female was housed inside the male stock box. This suggests that the latter situation supplies a stronger stimulus.

In both test situations the superiority of the wild-type males over the albinos as pregnancy blocking agents was highly significant. The reason for this difference is not understood, and as yet male mice of other strains have not been tried. Two different strains of females, one albino and the other pink-eyed champagne, were tested in small numbers in situation *B*. Both exhibited pregnancy block in similar proportions to those found for the original mice.

The use of the genetically marked wild-type test males showed that superfœtation did not occur. Of 35 females, 15 mated with the test male. All 15 gave birth to black-eyed young only (123 young). This includes one female in which coitus with the test male took place within a few hours of introduction, her litter of 8 black-eyed young being born 19 days later, 20 days after finding the vaginal plug from the stud albino male.

No mutual reaction between females as regards pregnancy block was indicated either when the test situation involved other females or when the mated females were themselves placed singly, in pairs, or in threes in the test situation. It is well established, however, that females exert a powerful effect upon one another in terms of the œstrous cycle[2] and the incidence of mammary cancer[3], and that the presence of a male tends to synchronize the cycle of non-pregnant females[4].

Further experiments designed to throw light on the mechanism involved in this pregnancy block of exteroceptive origin are in progress. The pituitary and the hypothalamus are probably both implicated.

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Retinal Responses of Pink Salmon associated with its Downstream Migration

The seaward migration of juvenile Pacific salmon is usually nocturnal and confined to a relatively brief portion of the night[1]. It has been suggested that "as the light intensity falls rheotactic responses, which are to a large degree dependent on vision, fail, and these fish pass down stream in shoals. The fact that such mass movements occur during a rather precise period of the night is probably due to the dark adaptation of the eye and a period of night blindness"[2]. In support of this view, a recent histophysiological examination of the retinæ from several species of *Oncorhynchus* has shown an incompletely dark-adapted condition of the retinæ at the time of most active downstream migration[3,4]. As a further test of this hypothesis, the retinæ from fish killed at different light intensities during the evening and early morning have been compared with the retinæ from fish which were completely adapted to the same light intensities in the laboratory. The pink salmon fry (*Oncorhynchus gorbuscha*), probably the most specialized of the downstream migrant salmon[1], was selected for the study.

Migrant pink salmon were collected from a trap in Jones Creek, British Columbia, and brought into a dark room of the laboratory. Groups of five fish were exposed for 90 min. to each of seven light intensities, ranging evenly from 10^{2} to 10^{-4} ft.-candle. The period of exposure was sufficient to bring about a complete adaptation[3,4]. Fish captured in the same place and in like manner were placed in glass aquaria which were located in an exposed position in the river where the fish had been migrating. The bottoms of the aquaria were covered with sand and gravel. From these aquaria, fish were sampled at seven times when the incident light intensity reached the same values used in the laboratory. This was done both at twilight and at dawn. Light intensities of 10^{-1} ft.-candle and greater were measured with 'Photovolt' model 200 photometer and light intensities below this value with 'Photovolt' model 520-*M* electronic photometer.

The eyes of teleost fish adapt themselves to altered light conditions by pronounced changes in the distribution of the retinal epithelial pigment and the position of the rods and cones. When the light intensity falls below threshold values, the retinal pigment concentrates and the rods and cones migrate due to the contraction and expansion, respectively, of their myoids. These movements are in direct proportion to the logarithm of the light intensity. Thus in bright light, the rods are shielded by the pigment and the cones placed directly in the path of light, whereas in low light intensities and darkness, the rods are brought directly in the path of light and the cones migrate closer to the concentrated pigment. These processes can be followed by measuring the thickness of the pigment and cone layers. The cones are more obviously delimited for this purpose than the rods. The histological techniques and methods of measuring retinal changes have been described[3,4]. The values presented here are means for 50 measurements made from 10 eyes in each case.

Fig. 1 shows that both pigment and cone layers of the pink salmon retina are in a semi-adapted state during the periods when the light intensity is rapidly changing in the evening and in the morning. The difference between the fully adapted laboratory picture and the semi-adapted state in Nature is less at dawn than in the evening. This is in accord with an earlier demonstration that light adaptation is more rapid than dark adaptation in this species[4]. Under natural conditions, in the evening, both pigment and cones are in a fully adapted state at intensities above 1 ft.-candle. However, between this level (the cone threshold) and 10^{-3} ft.-candle the retinæ of animals fixed in the field are not as completely adapted as those in the laboratory. At 10^{-4} ft.-candle adaptation is the same in both groups. It requires about 45 min. (Fig. 1) for the light intensity to fall from 1 to 10^{-4} ft.-candle. Ali[4] has shown that retinal adaptation commences below 1 ft.-candle and requires about 45 min. to reach a maximum. Thus, the changes in the field are in accord with the laboratory findings. With increasing light, retinal changes are evident at intensities above 10^{-2} ft.-candle and adaptation is essentially complete at 1 ft.-candle. The rapidity of light adaptation[4] would seem to account for the small differences found in the fish sampled at dawn. Actually, the changes in light intensity in Nature are somewhat more rapid at dawn than at dusk (Fig. 1).

These findings are in accord with the theory that migration of pink salmon is initiated when the retina is only partially adapted to the decreasing illumination. At Jones Creek, where these observations were made, it was found that 80 per cent of the pink migrants entered the trap between 7 p.m. and 9 p.m. (Pacific standard time) on the nights of the study.

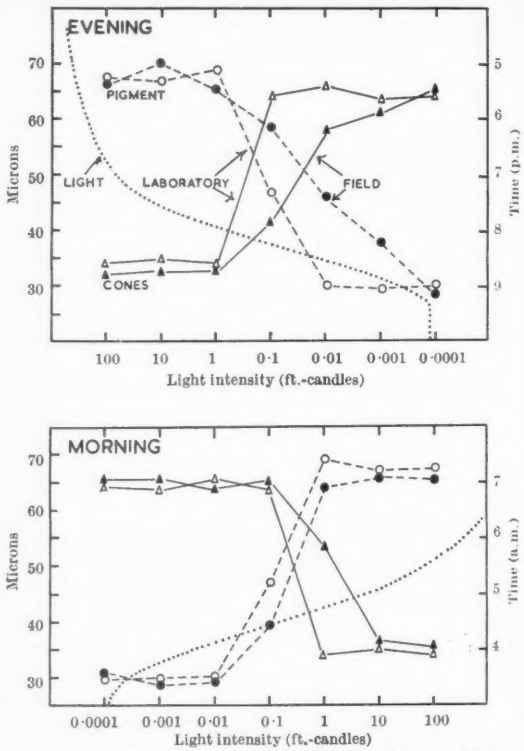

Fig. 1. Thicknesses of the pigment and cone layers of pink salmon retinæ when fully adapted to a series of light intensities in the laboratory and at the same intensities under conditions of rapidly changing morning and evening light in the field

During this period the light intensity decreased below 1 ft.-candle and reached 10^{-4} ft.-candle. It is not to be expected that all the fish will be affected at the same time since there are shaded and exposed areas in every stream. These observations, however, support well the theory that, whether the pink salmon is transported or actively swims downstream[1,5], its nocturnal movement will be initiated when visual contact with its environment is reduced or impaired. This will be associated with the rather specialized behaviour of rising to the surface of the water at low light intensities[1].

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Deoxyribonucleic Acid Formation in Multiplying HeLa Cells

While studying the behaviour of parasynchronously dividing HeLa cells (Gey), Newton and Wildy[1] have measured the amount of deoxyribonucleic acid as a function of the time-interval between one division and the next. Their results suggest that the synthesis of deoxyribonucleic acid occurs during two periods in interphase: one soon after and one just before cell division. Between these periods, in mid interphase, there exists an interval during which the amount of deoxyribonucleic acid (DNA) in the cell remains approximately constant (Fig. 1, curve *a*).

Partial confirmation of this result, using a microspectrophotometric technique, has been obtained in a further series of experiments made with randomly dividing cultures. Replicate cultures of HeLa cells were grown on cover-glasses held in 10-ml. hard glass screw-capped bottles. These were made by introducing into each bottle 1·0 ml. Gey's saline containing 20 per cent human serum, 0·5 per cent lactalbumin hydrolysate (Nutritional Biochemicals Inc.), 100 units/ml. penicillin, 100 mgm./ml. streptomycin and 0·002 per cent phenol red in which were suspended 250,000 separated cells. After incubating at 37° C.

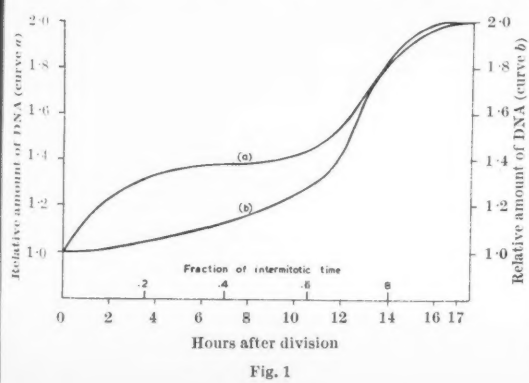

Fig. 1

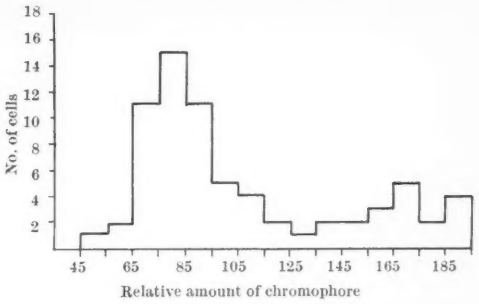

Fig. 2

for 36 hr. the cultures were fixed in methanol, stained by the Feulgen technique and the amount of chromophore per cell was measured for 70 cells (from two different cultures) by the two wave-length technique[2,3], using the microspectrophotometer made by M. L. Mendelsohn[4] in the Department of Radiotherapeutics, Cambridge. From these measurements a histogram has been constructed which shows the distribution of the chromophore, and hence the relative amounts of deoxyribonucleic acid, among the individual cells of the culture (Fig. 2).

Walker[5] has shown how the synthesis curve for deoxyribonucleic acid may, with certain restrictions, be constructed from such a histogram. It is believed that the cultures used for the estimation satisfied these conditions. Fig. 1, curve *b*, has therefore been constructed from the histogram of Fig. 2.

Comparing the curves in Fig. 1, it will be seen that whereas it is not possible to tell from Fig. 1*b* whether the early formation of deoxyribonucleic acid shown in Fig. 1, curve *a*, occurs, there is certainly a rapid synthesis beginning about 5 hr. before cell division and continuing up to a comparatively short time before cell division.

The late period of formation of deoxyribonucleic acid agrees with the findings of Walker and Yates[6] using other kinds of cells and with those of Painter and Drew[7] using tritiated thymidine on cultures of growing HeLa cells.

It is, however, difficult to explain the failure to detect the earlier rise in deoxyribonucleic acid which was found with parasynchronously dividing cultures, though the following two explanations should be considered: (1) that the present method is inadequate for demonstrating such a rise; (2) that the early rise is characteristic only of parasynchronously dividing cells. The latter explanation is thought to be more likely because in such cultures the early rise in deoxyribonucleic acid has never been observed before the first cell division has occurred.

A limit to the end of the synthesis period has been obtained by examining autoradiographs of cultures growing in the presence of tritiated thymidine. After 36 hr. growth, tritiated thymidine (Schwarz 3·0 c./m*M*.) was added to the medium to give a concentration of 1 μc./ml. and, 30 min. later, the culture was fixed in methanol. The cells were afterwards stained with gallocyanin and autoradiographs were prepared. In these, although interphase cells were well labelled, examination of several hundred cells in all stages of mitosis showed that none of them was labelled. From this it can be deduced that synthesis of deoxyribonucleic acid ends at least 1–1¼ hr. before the commencement of mitosis, since

the cells were in the thymidine for ½ hr. and the duration of mitosis is about 35 min.

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Induction of Parthenocarpy in *Rosa arvensis* Huds. with Gibberellic Acid

As has been previously reported[1], parthenocarpy may be induced in the two non-apomictic species, *R. rugosa* Thunb. and *R. spinosissima* L., by means of α-naphthaleneacetic acid, α-naphthaleneacetamide and 2 : 4 : 5-trichlorophenoxyacetic acid. Similar experiments were carried out in an attempt to induce parthenocarpic development in a third non-apomictic species, *R. arvensis*.

The auxin was applied in two ways to the unopened flower-bud, which was emasculated by cutting off the 'disk' (including the head of stigmas) immediately prior to treatment. In early experiments aqueous solutions of the auxins mentioned above and indoleacetic acid were injected into the cavity of the receptacle in concentrations ranging from 2 to 25 p.p.m. In later work the auxin was applied to the cut surface as a lanolin paste in concentrations of 0·025–1·0 per cent. Since *R. arvensis* differs from the other two species in having a much lower ascorbic acid content[2,3], additional mixtures, including ascorbic acid, were used.

Almost all these experiments produced negative results, the emasculated control hips usually surviving longer than those treated with auxin. Out of a total of about 300 buds treated, only four showed any signs of growth; these had received the lowest concentration of auxins in lanolin and two of them had had ascorbic acid.

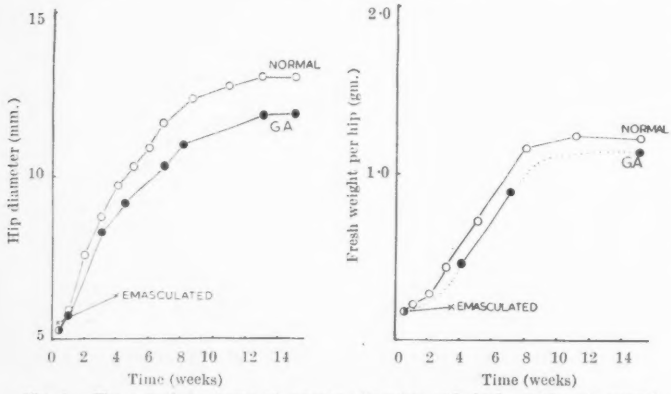

Fig. 1. The growth in terms of average diameter and fresh weight of normal hips, ○—○; emasculated flower-buds ×—×; and emasculated flower-buds treated with 1·0 per cent gibberellic acid in lanolin, ●—●

Since the development of rosaceous fruit after fertilization is characterized by increase in cell size rather than in cell number, the properties demonstrated for gibberellic acid suggested that it might be effective in inducing parthenocarpic development. In February 1958 parthenocarpic hips of *R. rugosa* were produced in the greenhouse by the application of gibberellic acid and shortly afterwards similar results were recorded for *R. spinosissima*[1].

In June 1958, 200 flower buds on a bush of *R. arvensis* were emasculated and 1·0 per cent gibberellic acid in lanolin was applied. Control groups of normal and emasculated buds were also selected; it had previously been shown that the application of lanolin alone produced no response. Samples from each group were harvested at intervals for determinations of fresh and dry weight, and Fig. 1 shows the development of the different groups of hips in terms of average hip diameter and fresh weight.

The main period of fruit-drop in *R. arvensis* is 3–5 weeks after flowering; 46 days after treatment with gibberellic acid 107 out of 150 hips were developing parthenocarpically, which represented a fruit-set of 71 per cent compared with 45 per cent for the normal, fertilized hips under these field conditions. None of the emasculated buds developed. Of the 57 parthenocarpic hips allowed to remain until maturity at 14 weeks after treatment, 48 had the appearance of normal, ripe hips while the other nine were smaller and not fully pigmented.

The *Triticum* coleoptile straight-growth test of Luckwill[4,5] showed that normal hips appear to contain two acidic, growth-promoting substances having R_F values of 0·1–0·2 and 0·4–0·5 in *iso*propanol/ammonia/water, and a neutral, growth-promoting substance with an R_F of 0–0·1 which is present in small quantities in the bud and flowering stages but which could not be detected 17 days after flowering, or in subsequent assays. None of these three substances was found in either parthenocarpic hips or emasculated controls, but a neutral growth-substance (R_F = 0·4–0·6) was present in the emasculated hips and an apparently identical substance was found in the parthenocarpic hips. A consistent growth-inhibitory effect was present in the tests, predominantly in the acid fraction and centred at R_F 0·8 in all stages of normal, emasculated and parthenocarpic hips.

The relationship between achene development and variations in the amount of growth regulators will be reported elsewhere.

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HÆMATOLOGY

Anti-A Hæmagglutinins from a Non-Leguminous Plant—*Hyptis suaveolens* Poit

CERTAIN plants, chiefly their seeds, contain agglutinins for the erythrocytes of various species. Whereas most plant agglutinins make no individual distinctions among human erythrocytes, some act selectively on one or other of the following blood-group antigens[1]: A, A_1, B, H and N. Except for separable anti-H and anti-B agglutinins from the seed capsule of certain species of *Euonymus*, of the family Celastraceae, all specific seed agglutinins have hitherto been obtained from Leguminosae[1].

An anti-A agglutinin has now been found in the seeds of *Hyptis suaveolens*, Poit, of the genus Labiatiae. The agglutinin works best when a fresh seed extract is tested on a flat tile which is gently and continuously rocked. Although it is not very avid when tested with erythrocytes suspended in isotonic saline solution, it agglutinates A_1 and A_1B cells strongly, A_2 weakly, and fails to agglutinate A_2B cells. Thus *Hyptis suaveolens* seed extract sharply differentiates A_1 and A_1B erythrocytes from those of the weaker sub-groups of A and AB; however, it is not as satisfactory for this purpose as *Dolichos biflorus* seed extract[2], which is far more avid.

The *Hyptis suaveolens* agglutinin acts as strongly at 37° C. or 4° C. as at room temperature. It does not cross-react with B or O cells after 24 hr. at 4° C. or when erythrocytes are suspended in albumin; albumin, however, potentiates the agglutination of A_2 and A_2B cells. Agglutination is inhibited by A-secretor saliva and by AB serum. A full description will be presented elsewhere.

The 'new' agglutinin is of special interest because it is the first seed anti-A (anti-A_1) agglutinin to be found outside the Leguminosae. The current trend is to confine the search for specific seed agglutinins to leguminous plants; wide examination of other plant families might be profitable.

I am grateful to D. S. Das for collecting the seeds and for technical assistance. The seeds were identified by the Botanical Survey of India, Poona.

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Interaction of Erythrocytes and Endotoxins

CONSIDERABLE diversity of opinion exists as to the sensitivity of hæmagglutination tests. The discrepancy in results may to some extent be attributed to technical differences. The factors influencing the reaction, the elution of endotoxin *in vitro* and the uptake by erythrocytes *in vivo* have been examined using a dehydrated endotoxin derived from *S. typhi* (*TO*-901). This powder consisted of 68·5 per cent ash, 7·8 per cent moisture, 1·6 per cent protein, 2·2 per cent lipids and, based on L-rhamnose hydrate as standard, 2·7 per cent rhamnose. If the method of calculation described by Webster *et al.*[1] is adopted the polysaccharide content is 14·3 per cent and the endotoxin approximately 20 per cent. The powder was dissolved in isotonic saline, heated to 56° C. for 30 min. and stored at 4° C. for at least 24 hr. before use. The solution had a slight buffer action, *p*H 7·2. Erythrocytes from healthy rabbits were washed and measured with the hæmatocrit. A volume of 0·2 ml. packed cells was used in most experiments.

Endotoxin was adsorbed on to the washed and measured erythrocytes at 37° C. for 1 hr. The cells were then washed three times in 6–8 volumes of isotonic saline and accurately made up to a 20 per cent suspension. Agglutination was performed on slides, using 0·05 ml. of sensitized erythrocytes and an equal volume of a diluted standard *TO*-serum. The slide was agitated regularly and the test read after exactly 10 min.

The amount of endotoxin adsorbed on erythrocytes was dependent on both the absolute quantity of endotoxin available and on its concentration. The speed of the process was proportional to the concentration of endotoxin and related to the temperature, being five to six times faster at 37° C. than at 4° C.

Erythrocytes coated with very small amounts of endotoxin were inagglutinable in antiserum, whereas those with greater quantities of endotoxin agglutinated readily. This afforded the basis for the determination of an 'erythrocyte-agglutinating unit', defined as the smallest amount of endotoxin, incubated with 2 ml. of 10 per cent erythrocytes for 1 hr. at 37° C., which rendered the cells agglutinable in standard serum diluted 1 in 10. One erythrocyte-agglutinating unit was found to be equivalent to 0·16 mgm. of the dehydrated powder. The quantity of crude endotoxin adsorbed on erythrocytes in these circumstances was 0·12 mgm., thus removing 75 per cent of endotoxin from the supernatant. Assuming the crude powder contains 20 per cent endotoxin it appears that 0·2 ml. of agglutinable packed cells under our experimental conditions must be coated with a minimum of 24 μgm. of endotoxin.

Erythrocytes, initially sensitized with sub-agglutinable quantities of endotoxin, became agglutinable on subsequent exposure to endotoxin provided that the sum of the two doses constituted at least one erythrocyte-agglutinating unit. Thus the erythrocytes appear to bind the adsorbed endotoxin quite firmly.

Assuming that the endotoxin was not removed or rendered undetectable except by fixation to erythrocytes, the reduction in endotoxin content as measured by determination of the erythrocyte-agglutinating unit on the supernatant, will be a direct, quantitative expression of adsorption. Experiments along these lines indicated that erythrocytes were capable of binding at least 200 times the minimum amount required for agglutination under standard conditions: that is to say 0·2 ml. packed cells could adsorb more than 200 × 24 μgm. or 4·8 mgm. of endotoxin as calculated, corresponding to 2·2 per cent of their own weight.

Erythrocytes of the same batch, coated with amounts of endotoxin ranging from 1 to 200 erythrocyte-agglutinating units, gave final agglutination titres against the standard serum ranging from 1 : 10 to 1 : 1,280. Hence, the titre of a given serum will vary according to the quantity of endotoxin adsorbed on to the cells. This may explain, at least partially, the discrepancy and inconsistency in results obtained by hæmagglutination tests; it could be overcome by rigorous standardization for which accurate measurement of endotoxin is essential.

Elution of endotoxin at our experimental conditions (*p*H 7·2–7·3) was minimal. Erythrocytes coated with 1·5 times minimum agglutinating dose of endotoxin

were still agglutinable after 12 washings in saline at room temperature. Thus, on the assumption that the stability of an erythrocyte suspension is unaffected by washing, it may be concluded that elution is of a low order. Since this could not be measured in erythrocyte-agglutinating units, a technique for estimating smaller quantities of endotoxin in solution was provided by the construction of a dose-response graph in rabbits. The maximum antibody response, as measured by bacterial agglutination, was directly proportional to doses of crude endotoxin ranging from 0·01 μgm. to 1 mgm. Using the dose-response technique for endotoxin estimation, further studies on elution at room temperature showed that endotoxin was released, but that this did not amount to 1 per cent of the adsorbed endotoxin per equivalent volume of saline. Whether the eluted endotoxin originated from intact or disintegrated erythrocytes has not as yet been established; but it is noteworthy that the washings caused slight hæmolysis.

Sensitized, washed cells inoculated intravenously into non-immune rabbits were highly antigenic. A single injection of a suitably adjusted erythrocyte suspension produced, in 7–10 days, agglutination titres up to 1 : 100,000. The serum of a rabbit previously immunized by endotoxin produced hæmagglutination *in vitro* against its own sensitized cells. Hæmolysis occurred on the addition of complement. Intravenous inoculation of 20 ml. of 50 per cent suspension of these erythrocytes, which agglutinated *in vitro* with the recipient's serum, boosted the antibody production. The animals failed to produce an acute intravascular episode. Nor was there conclusive evidence of a hæmolytic process as measured by serum bilirubin estimations and Schumm's test. This tolerance of what is a serologically incompatible transfusion is unexplained.

In vivo sensitization in rabbits was demonstrated by intravenous injection of large doses of endotoxin. The animals were bled 4 hr. later and the erythrocytes, washed six times in excess saline, were inoculated intravenously into non-immune rabbits. They responded with a significant antibody production. Which part the adsorption *in vivo* plays in the defence against endotoxins has not as yet been established.

Details of these experiments will be published elsewhere.

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BIOCHEMISTRY

Interaction of Sucrose Stearate with Starch

It is generally agreed that changes in the starch component of flour are responsible for the staling of bread[1]. Following a report by Bohn[2] that the sucrose stearates are effective as anti-staling agents, a study was made of the interaction of starch with a commercial sample of sucrose stearate, kindly supplied by F. D. Snell, Inc.

Addition of a sucrose stearate solution to a 1 per cent solution of 'AnalaR' starch in 0·1 per cent sodium chloride resulted in the precipitation of some starch. The maximum amount of precipitate (about 20 per cent of the weight of starch) was obtained with concentrations of sucrose stearate above 0·06 per cent.

Extension of the study to undegraded starches (Table 1) showed that the amount of precipitate depended upon the type of starch. Fractionation of the potato starch into amylose and amylopectin[3] followed by precipitation with excess sucrose stearate showed that most of the amylose but little of the amylopectin was precipitated (see Table 2). Treatment with excess sucrose stearate of an artificial mixture of amylose and amylopectin in the ratio in which they occur in starch gave a figure intermediate between that of the whole starch and that which would be expected on the basis of the separate amylose and amylopectin precipitations. These results indicate that the amylopectin is precipitated more efficiently in the presence of amylose than in its absence.

Table 1. Precipitation of Starches by Sucrose Monostearate

Type of starch	Polysaccharide concentration (per cent)	Sucrose monostearate concentration (per cent)	Precipitate (per cent of polysaccharide)
'AnalaR' starch	1·0	0·1	21·6
Potato starch	1·0	0·1	70·9
Wheat starch	1·0	0·1	92·4
Waxy maize starch	1·0	0·1	13·0

Table 2. Precipitation of Starch Fractions by Sucrose Monostearate

Type of starch fraction	Polysaccharide concentration (per cent)	Sucrose monostearate concentration (per cent)	Precipitate (per cent of polysaccharide)
Potato starch	0·4	0·04	72·7
Potato amylose	0·4	0·04	79·9
Potato amylopectin	0·4	0·04	11·1
20 per cent amylose, 80 per cent amylopectin	0·4	0·04	43·9

Controlled acid hydrolysis of potato starch showed that a high molecular weight was important in determining the amount of precipitate formed with sucrose stearate and it is likely that the low yield of precipitate from 'AnalaR' starch could be attributed to this factor.

A study of the change in diameter of wheat starch granules on heating in aqueous suspension in the presence and absence of sucrose stearate showed that the rate of swelling was reduced in the presence of sucrose stearate. From an examination of the change in turbidity on heating wheat starch suspensions (0·1 per cent), it appeared that in the presence of 0·01 per cent sucrose stearate the gelatinization temperature is raised about 10 deg.

As sucrose stearate is firmly bound by starch, it seemed likely that it would interfere with the starch/iodine reaction. This was shown to be so, and that iodine and sucrose stearate compete for the amylose fraction. There was no evidence for any marked interaction between sucrose stearate and amylopectin by this technique. It is possible that the stearate chain of the sucrose stearate mole-

cule occupies a position down the centre of an amylose helix, in the same way that iodine does[1].

A complete account of this work will be published elsewhere.

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Influence of X-Rays on the Activity of Carbonic Anhydrase in Erythrocytes and on their Hæmolytic Resistance

Since sickle cell anæmia is possibly related to the activity of carbonic anhydrase[1], it is of interest to find some way of inhibiting the enzyme without altering the resistance of the cell membrane. Carbonic anhydrase is very stable[2] but its activity can easily be changed experimentally by adjusting the *p*H and temperature, or by adding sulphonamides or certain inorganic ions. All these factors, however, have a marked influence on hæmolysis, whereas erythrocytes seem to be rather resistant to X-rays[3]. We therefore decided to examine whether carbonic anhydrase could be inhibited by a dose of X-rays which would have little or no effect on hæmolysis.

For the determination of the enzyme activity we designed an improved Warburg technique[4]. This method is based upon measuring the rate of evolution of carbon dioxide when a bicarbonate solution is treated with a buffer and the enzyme. We calculated the unimolecular velocity constant of the reaction, which is also used as an index of activity by Mitchell, Pozzani and Fessenden[5]. The standard error of our measurements was 12 per cent and for the non-catalysed reaction 4 per cent. As a measure of the hæmolytic resistance we used the hæmolytic index: this is, in conventional experimental conditions[6], the highest dilution of lysin which produces 100 per cent hæmolysis within 2 hr. The standard error of our hæmolytic indices was 2·5 per cent. Suspensions of 10^7 cells/cm.^{3} in physiological saline solution were irradiated in vessels of 2 cm.^{3}; dose 100,000 r., instrument Philips 'Compactix', 210 kV., h.v.l. = 4 mm. of aluminium, dose-rate 6,700/min.

In non-irradiated blood we found the following carbonic anhydrase activities, calculated per cubic centimetre of full blood: ox blood, 1·85 Mitchell units; human blood, 1·4; chicken blood, 1·2. Irradiations of four samples of ox blood, two samples of human blood and two samples of chicken blood had no effect on the activity. Repeating this dose after 24 hr. yielded no inhibition. Solutions of purified enzyme (Schering's 'Cartase', 0·1 per cent), treated in the same way, showed an inactivation of 20 and 50 per cent respectively. The fact that these high doses of X-rays do affect erythrocytes in other respects, was shown by their hæmolytic index: in our controls this was 13,300 with saponinum album (Merck); after irradiation, the index was increased by 10 per cent and after the second dose of 100,000 r. the increase was 17 per cent.

Our experiments confirm the great stability of carbonic anhydrase, and indicate that this stability is still greater inside the red blood cell: we found no decrease in activity of the carbonic anhydrase of erythrocytes after irradiation with 200,000 r. The hæmolytic resistance of the cells was clearly diminished by this dose, so that it is possible that irradiation by X-rays will permit us to modify the structure of the cell-membrane without altering its carbonic anhydrase activity.

We wish to thank Prof. R. Ruyssen for advice and encouragement and Prof. Van Vaerenberg, who provided the necessary X-ray equipment.

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A Method for distinguishing between α- and β-Glycosides by the use of Plant Hæmagglutinins (Lectins)

Several plant seeds contain proteins that agglutinate red blood cells[1,2] as do many antibodies. For these proteins the name 'lectins' has been suggested[3]. They can be as specific as animal antibodies in that they react only with erythrocytes of certain blood groups. The ABO blood group specific lectins—as well as the ABO specific antibodies—are inhibited by some simple sugars, mainly components of blood group polysaccharides[1,2,4]. Several 'unspecific' lectins are also inhibited by simple sugars, but these sugars are not necessarily components of blood group polysaccharides[1,2]. The explanation of this phenomenon is that the sugars, the structure of which most closely resembles the specific (sugar) group of the red cell receptor, attach themselves to the active site(s) of the lectin molecule, thus blocking them.

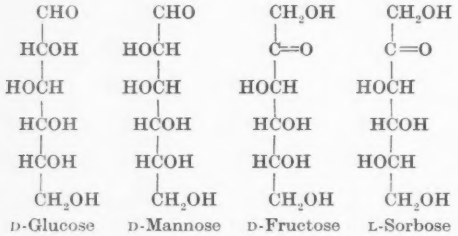
A monosaccharide as a rule retains its inhibiting power even when linked to other sugars through the hydroxyl group of the first (in ketoses, the second) carbon atom[2,5]. The type of link, whether α or β, seems to be significant. In order to throw light on this problem, I made plant agglutinin inhibition tests by a method described in detail elsewhere[6].

The following sugars were used in all experiments: D-glucose, D-glucosamine, N-acetylglucosamine, D-

glucuronic acid, D-gluconic acid, D-xylose, D-mannose, D-fructose, L-sorbose, D-galactose, D-galactosamine, N-acetyl-D-galactosamine, D-fucose, L-arabinose, D-talose, L-galactose, L-fucose, D-arabinose, D-ribose, D-digitoxose, L-rhamnose, maltose, sucrose, turanose, trehalose, cellobiose, gentiobiose, melibiose, raffinose, and lactose.

Seeds of *Pisum sativum* L., *Cytisus sessilifolius* L., *Bandeiraea simplicifolia* Benth., and *Crotalaria juncea* L. were used. The lectin solutions were prepared by incubating a mixture of seed powder (1 part) and physiological saline (9 parts) for 2 hr. at 37° C. After centrifugation the supernatant was used. 0·05 ml. of seed extract containing 2–4 agglutinating doses of lectin and 0·05 ml. of sugar solution (*p*H 7·0) in saline were mixed, and after 30 min. incubation at 20° C. 0·05 ml. of a suspension containing 3 per cent human red cells in saline was added. After 2 hr. further incubation at 20° C. the tubes were read for agglutination. The quantitative inhibiting power of the sugars was measured by preparing two-fold serial dilutions of them.

The results are shown in Tables 1 and 2. The figures give the final concentration of sugar. Of the sugars tested (see above) only those which inhibit either *Pisum sativum* or *Cytisus sessilifolius* lectin at a concentration of 0·08 *M* are included in Table 1. The *Pisum* lectin is strongly inhibited by D-glucose, D-mannose, D-fructose and weakly by L-sorbose. The structural differences between the first three sugars are confined to carbon atoms 1 and 2. L-Sorbose differs from D-fructose only with regard to carbon atom 5, but its inhibiting activity is far lower. D-Glucuronic acid and D-gluconic acid are not inhibitory.



It will be seen from the second part of Table 1 that α-glucosides inhibit agglutination by *Pisum* extract as effectively as D-glucose, while β-glucosides are not inhibitory. Sucrose is not only an α-glucoside but a β-fructoside as well; however, the fructose part is not probably responsible for the inhibition, since another β-fructoside, raffinose, has no effect on *Pisum* lectin. An agglutination by *Cytisus* extract, on the other hand, is inhibited by β-glucosides but not by α-glucosides. The failure of glucose itself to inhibit the *Cytisus* lectin is difficult to explain unless it is due to the hexose molecule being too small.

Table 1

Sugar		Minimum amount of sugar (m.moles/l.) inhibiting the action of *Pisum sativum* lectin	Minimum amount of sugar (m.moles/l.) inhibiting the action of *Cytisus sessilifolius* lectin
	D-Glucose	1·25	>80
	D-Glucosamine	5	>80
	N-Acetyl-D-glucosamine	2·5	>80
	D-Mannose	0·6	>80
	D-Fructose	2·5	>80
	L-Sorbose	40	>80
	(Lactose)	>80	40
α-Glucosides	Maltose	1·25	>80
	Sucrose	2·5	>80
	Turanose	0·6	>80
	Trehalose	0·6	>80
β-Glucosides	Cellobiose	>80	5
	Gentiobiose	>80	40

Table 2

		Minimum amount of sugar (m.moles/l.) inhibiting the action of *Bandeiraea simplicifolia* lectin	Minimum amount of sugar (m.moles/l.) inhibiting the action of *Crotalaria juncea* lectin
	D-Galactose	0·6	5
	D-Galactosamine	5	>80
	N-Acetyl-D-galactosamine	0·4	
	D-Fucose	2·5	20
	L-Arabinose	5	20
	D-Talose	20	
	L-Rhamnose	40	>80
α-Galactosides	Melibiose	0·3	5
	Raffinose	0·3	20
β-Galactoside	Lactose	20	1·25

It seems possible, on the basis of the above results, to ascertain the type of the glycosidic link (α or β) of D-glucose, perhaps also of glucosamine, acetyl-glucosamine, D-mannose, in disaccharides and other oligosaccharides the structure of which is only partially known.

There are other lectins (*Bandeiraea simplicifolia* and *Crotalaria juncea*) by means of which it seems possible to obtain information of the type of the D-galactosidic (and perhaps D-fucosidic, L-arabinosidic, etc.) link, even though the differences between α- and β-galactosides are less definite (Table 2) than differences between α- and β-glucosides (Table 1). Unfortunately the number of galactosides tested is small.

If need be, the determinations can be made with 0·01–1 mgm. of sugar, and the solution need not be pure; many amino-acids and other sugars, for example, do not interfere. There are other methods of studying the nature of the glycosidic link, but the amount of sugar needed for enzymatic or polarimetric studies is greater. The information obtained by chromatographic or infra-red spectrographic studies is limited unless an adequate stock of reference compounds is available.

Of the seeds quoted above only those of *Bandeiraea simplicifolia* may be difficult to get. The rest are obtainable from many seed shops, and can even be replaced by other related species[2]. The *Bandeiraea* lectin is blood group B specific—it can be used with B erythrocytes only; and *Cytisus* lectin is O(H) specific—it should be used with O cells. The other lectins can be used with red cells of any blood group.

The ability of lectins to differentiate between α- and β-glycosides supports J. Lederberg's (personal communication) suggestion that there is some connexion between them and plant glycosidases. Lectins are not, however, likely to be true glucosidases because (*a*) they are present in ungerminated seeds and their amount does not increase appreciably after germination[7], (*b*) there is no correlation in occurrence between lectins and glycosidases in plant species[8], and (*c*) several purified lectin preparations have been found not to hydrolyse the disaccharides which inhibit agglutination[8].

The monosaccharide specificity of lectins seems to be less definite than that of glycosidases, though

glycosidases are not strictly specific; the members of a certain homomorphous sugar series (sugars with an identical pyranose or furanose ring) behave more or less alike as substrates of glycosidases[9], but many lectins are inhibited by members of two homomorphous series. These series can differ with regard to the substituents of carbon atom 2. Thus *Pisum* lectin is inhibited by D-glucose and D-mannose, *Bandeiraea* lectin by D-galactose, D-fucose, L-arabinose and D-talose (see above), and *Lotus tetragonolobus* lectin by L-galactose, L-fucose, D-arabinose and 6-deoxy-L-talose[4]. The substituents in carbon atoms 3 and 4 seem to be of the greatest importance to the capacity of monosaccharides to inhibit lectins, a view which was expressed six years ago by Morgan and Watkins[4] with regard to *Lotus tetragonolobus* lectin.

I wish to thank Mr. E. R. Vaughan, curator, Botanical Garden, University College of Ghana, who kindly sent me several samples of *Bandeiraea simplicifolia* seeds.

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Reactivity and Interrelationship of Intermediates in the Hydrolysis of *p*-Nitrophenyl Acetate Catalysed by Chymotrypsin

KINETIC studies by Gutfreund and Sturtevant[1] suggest that *p*-nitrophenyl acetate reacts with chymotrypsin rapidly at a *p*H greater than 6·5 to form monoacetyl chymotrypsin (*AC*–I) and that *AC*–I is then deacylated slowly. The kinetic observations are consistent with the esterification of a single serine hydroxyl of the enzyme[2]. In contrast, spectroscopic studies[3] of the deacylation of monoacetyl chymotrypsin formed at *p*H 5·0 and isolated according to the procedure of Balls and Wood[4], (*AC*–*A*), show that when *AC*–*A* is brought to *p*H 9·0, a rapid increase in absorption at 245 mμ occurs which is followed by slow decay of the absorption peak. Since both the absorption peak and its rate of decay appeared characteristic for N-acetyl imidazole, Dixon and Neurath[3] suggested that the deacylation of monoacetyl chymotrypsin proceeds by a rapid intramolecular shift of the acetyl group from a serine oxygen to an imidazole nitrogen of the enzyme (*AC*–II), and that the rate-limiting step of the enzymatic reaction is the base-catalysed hydrolysis of N-acetyl imidazole. Recently, however, we have observed[5] that *AC*–I and *AC*–*A* are deacylated at different rates as measured by the liberation of *p*-nitrophenol from *p*-nitrophenyl acetate catalysed by *AC*–I and *AC*–*A*, and that *AC*–I is converted to *AC*–*A* under the conditions used in the isolation procedure[4].

The result of investigations reported below further delineate the differences between *AC*–*A* and *AC*–I, and suggest an interrelationship between *AC*–*A*, *AC*–I and *AC*–II as well as a structure for *AC*–*A*. The experiments illustrated in Fig. 1 indicate that *AC*–*A* (salt-free α-chymotrypsin, recrystallized three times; gift of the Sigma Chemical Co., St. Louis, Missouri) cannot be deacylated via a single intermediate which decomposes with a single rate-constant identical with the rate of decay ($1·7 \times 10^{-3}$ sec.$^{-1}$)[3] of the 245-mμ absorption peak. Curve 1 represents α-chymotrypsin pre-acetylated for 10 min. at *p*H 5·0 with 100 equivalents of *p*-nitrophenyl acetate and mixed at zero time with buffer such that the final *p*H was 8·0. Zero-order steady-state liberation of *p*-nitrophenol is observed within 15 sec. The rate of deacylation (k_3) of this enzyme (*AC*–I) calculated from the observed rate of liberation of *p*-nitrophenol is $1·6 \times 10^{-2}$ sec.$^{-1}$ at 15·6° C. Curve 2 represents an experiment in which *AC*–*A* was mixed at zero time with *p*-nitrophenyl acetate at *p*H 8·0. The rate of liberation of *p*-nitrophenol during the first 30 sec. is only about 70 per cent of the rate observed in curve 1 (*AC*–I), and essentially the same as *AC*–I after 300 sec. The deviation from zero-order kinetics observed during the first 300 sec. of the reaction of *AC*–*A* with *p*-nitrophenyl acetate is interpreted as indicative of the rates of reactions involved in the conversion of *AC*–*A* to *AC*–I. These reactions are presumably the deacylation of *AC*–*A* and its reacylation at *p*H 8·0 to form *AC*–I. However, the rate of conversion of *AC*–*A* to *AC*–I is incompatible with the complete deacylation of *AC*–*A* via the N-acetyl imidazole intermediate (*AC*–II), as can be seen

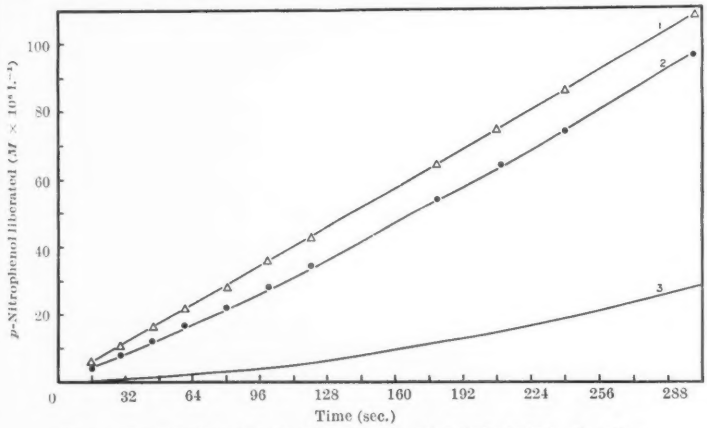
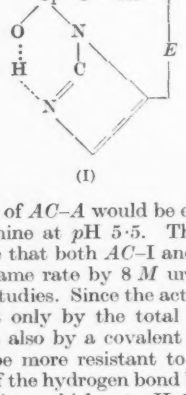


Fig. 1. The liberation of *p*-nitrophenol in the catalytic hydrolysis of *p*-nitrophenyl acetate by α-chymotrypsin and monoacetyl-α-chymotrypsin preparations at 15·6° C. in *tris*-(hydroxymethyl)-aminomethane–maleate buffer, *p*H 8·0. Total ionic strength 0·12 *M*; $[E]_0 = 2·1 \times 10^{-5}$ *M* $[S]_0 = 1·7 \times 10^{-3}$ *M*. Curve 1, chymotrypsin preacetylated for 10 min. with 100 equivalents of *p*-nitrophenyl acetate at *p*H 5·0 and 15·6° C. and then mixed with buffer at zero time to bring the *p*H to 8·0; curve 2, isolated monoacetyl-α-chymotrypsin (ref. 4) (*AC*-*A*); curve 3, a calculated curve for the catalysis of *p*-nitrophenyl acetate by a monoacetyl enzyme which is deacylated with a rate of $1·7 \times 10^{-3}$ sec.$^{-1}$

from curve 3. Curve 3 was calculated for a monoacetyl enzyme which is deacylated at a rate characteristic for N-acetyl imidazole ($k = 1{\cdot}7 \times 10^{-3}$ sec.$^{-1}$ at *p*H 8·0). Since curves 2 and 3 are not identical one must assume from the spectroscopic studies that the deacylation reaction of *AC*–*A* can proceed via *AC*–II only partially if at all. The rate between the first 15 and 30 sec. of reaction in curve 2 is about 70 per cent of the final rate, in curve 3 only about 2 per cent of the final rate. It appears, therefore, that only about 30 per cent of *AC*–*A* can be deacylated via *AC*–II. This is consistent with the observation that the absorption at 245 mμ accompanying the deacylation of *AC*–*A* corresponds to only about 0·4 mole of N-acetyl-imidazole per mole of acetyl-enzyme.

The kinetic results appear consistent with two alternatives. *AC*–*A* is either an equilibrium mixture of 70 per cent *AC*–I and 30 per cent of a form of monoacetyl-enzyme which is deacylated via *AC*–II or *AC*–*A* is a single intermediate which under the conditions used for hydrolysis of *p*-nitrophenyl acetate gives rise to the two separate intermediates, *AC*–I and *AC*–II.

To test which of these alternatives is correct, *AC*–I and *AC*–*A* were allowed to react with hydroxylamine[4] at *p*H 5·5. When the reaction was carried out in water both *AC*–I and *AC*–*A* reacted to form approximately 1 mole of hydroxamate per mole of enzyme. After both preparations were denatured for 2 min. in 8 *M* urea at *p*H 5·5 and 23° C. the acetyl group of *AC*–I was completely unreactive toward hydroxylamine while that of *AC*–*A* was completely reactive. Since all the acetyl groups of *AC*–*A* were capable of forming an hydroxamate under conditions which abolish the activity of *AC*–I, then it follows that none of the acetyl groups in *AC*–*A* are present in the same form as they are in *AC*–I. The activity of *AC*–*A* toward hydroxylamine can be destroyed by denaturing for 10 min. at *p*H 5·5 and 23° C. or for 2 min. at *p*H 3·0 and 23° C. These facts are taken into account in proposing the structure for the active site of *AC*–*A*:



(I)

The active site of *AC*–*A* would be expected to react with hydroxylamine at *p*H 5·5. The results shown in Fig. 2 indicate that both *AC*–I and *AC*–*A* are denatured at the same rate by 8 *M* urea as judged by optical rotation studies. Since the active site of *AC*–*A* is stabilized, not only by the total configuration of the molecule but also by a covalent and a hydrogen bond, it would be more resistant to treatment with urea. Removal of the hydrogen bond by urea forms an anionic intermediate which, at *p*H 5·5, leads to the formation of the *O*-acetyl derivative (*AC*–I), which is unreactive toward hydroxylamine in urea solution. At *p*H 3·0, the rate of denaturation is faster than at *p*H 5·5 as shown in Fig. 2, explaining why the reactivity of *AC*–*A* toward hydroxylamine is abolished

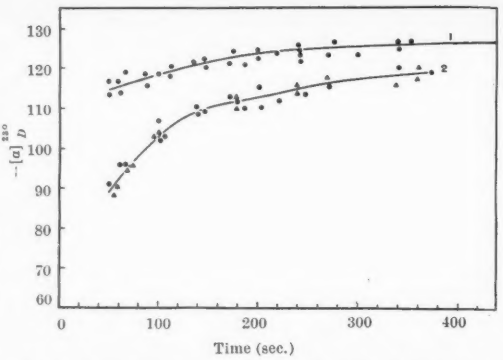


Fig. 2. Change with time of the specific rotation of α-chymotrypsin (*CT* ...) and isolated monoacetyl-α-chymotrypsin (ref. 4) (*AC*-*A* △-△) in 8 *M* urea at 23° C. in 0·05 *M tris*-(hydroxymethyl)-aminomethane–maleate buffer at *p*H 5·5 (curve 2), and in 0·05 *M* sodium citrate buffer at *p*H 3·0 (curve 1). Optical rotation was measured in a Rudolph photoelectric spectro-polarimeter

after 2 min. in 8 *M* urea at *p*H 3·0. Under basic conditions, such as those used for the kinetic experiments, *AC*–*A* would be expected to form both the *O*- and the *N*-acetyl derivatives *AC*–I and *AC*–II, by nucleophilic attack at C_1.

The proposed active site of *AC*–*A* explains the spectroscopic and kinetic results as well as the reactivity toward hydroxylamine.

AC–I is kinetically identical to the normal acetyl-enzyme at *p*H 7·0–9·0. Since no significant change in absorption at 245 mμ accompanies the hydrolysis of *AC*–I[5b], there is no evidence for *N*-acetyl-imidazole as intermediate in the normal catalytic reaction.

This investigation was supported by grants from the U.S. Public Health Service and the National Science Foundation. We are indebted to Dr. Lyman C. Craig, Rockefeller Institute, New York City, for the use of the Rudolph photoelectric spectro-polarimeter.

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Effect of Purine and Pyrimidine Analogues on Reversion of a Tryptophan-requiring Strain of *Escherichia coli*

We suggested recently that nucleic acid precursors, altered *in vivo* by ultra-violet light, are involved as chemical intermediates in the induction of mutation[1]. We have since reported that, in the absence of an adequate source of nitrogen, an immediate and rapid decline in the frequency of mutations induced by ultra-violet light occurs ('mutation frequency decline')[2]. We demonstrated that the prevention of this decline depends on the availability immediately

following exposure to radiation of a supply of amino-acids, and suggested that the amino-acids are involved in a process of temporary 'stabilization' of the 'potential mutation' (the modified purine or pyrimidine) in the cell prior to its effect in the induction of mutation ('mutation stabilization')[2]. The potential mutation is ultimately 'fixed' into the cell and is no longer subject to those conditions which previously resulted in decline in mutation frequency ('mutation fixation')[2]. Recently we have reported that the progression of 'mutation fixation' is closely correlated with the synthesis of ribonucleic acid in the culture, and suggested that the initial mutagenic event involves the incorporation of the modified nucleic acid precursor into ribonucleic acid[3]. We wish to report here experiments which determine the effect of certain purine and pyrimidine analogues on reversion induced by ultra-violet light in an auxotrophic strain of *Escherichia coli*.

The mutations studied result in reversion to the prototrophic state of *E. coli* strain *WP*[2] (tryptophan-requiring strain of Witkin)[2]. The basic procedure followed for culture growth, synchronization, radiation exposure, culture treatment, plating and mutation assay have already been described[1,2]. The procedures used for the determination of nucleic acid and protein have also been described[3].

30 purine or pyrimidine analogues were tested by addition (5 mgm./100 ml.) to incubating cultures immediately following exposure to radiation. The substances tested were: 5-bromouracil, thiouracil, 5-methylorotic acid, 5-thioguanine, 8-aza xanthine, 6-aza uracil, caffeine, 5-nitrouracil, 6-aza thymine, 8-aza guanine, 8-aza hypoxanthine, 8-aza adenine, 6-methylthiouracil, 5-aminouracil, 5,6 dichloro-1-(β-D-ribofuranosyl) benzimidazole, 5-bromodeoxyuridine, 5-hydroxyuridine, 5-methylthiouracil, 8-aza xanthine, uramil, diazouracil, 6-mercaptopurine, dithiouracil, 5-nitrouracil, 2-amino-4-methyl pyrimidine and 5-bromouridine. The effect of each on mutation response was determined by plating the cells on the mutation assay agar after 60 or 80 min. incubation with the analogue. Of these analogues, 6-mercaptopurine, 5-hydroxyuridine and 6-aza uracil were found to have a marked effect on the mutation frequency response while 6-thioguanine and 5-nitrouracil lowered the mutation response slightly. Preliminary studies with 5-hydroxyuridine have been reported elsewhere[3].

The decline in mutation frequency promoted by 5-hydroxyuridine is initiated after a lag of some 20 min. and is complete after incubation for 60 min. (Table 1). The initiation of the decline in mutation frequency in the presence of 5-hydroxyuridine is correlated with the initiation of synthesis of ribonucleic acid and is complete at about the time the relative amount of ribonucleic acid has doubled. Protein synthesis begins only after a considerable degree of decline in mutation frequency has occurred. Furthermore, synthesis of deoxyribonucleic acid is initiated after the decline promoted by 5-hydroxyuridine is complete. Thus the decline in mutation frequency in the presence of this analogue can be correlated with the synthesis of ribonucleic acid in the presence of the analogue. A plausible hypothesis to account for this fact is that the analogue is incorporated into ribonucleic acid, thus producing 'non-functional' ribonucleic acid and using up the mutagenic substrate. Preliminary studies indicate that 6-mercaptopurine may exert its effect through a similar mechanism.

Table 1. THE EFFECT OF 5-HYDROXYURIDINE ON MACROMOLECULAR SYNTHESIS AND THE YIELD OF ULTRA-VIOLET-INDUCED PROTOTROPHS FROM *Escherichia coli* STRAIN *WP2*

Post-irradiation incubation time† (min.)	5-Hydroxyuridine, 5 mgm./100 ml.*			
	Prototrophs per 10^8 survivors	Relative concentration		
		RNA	Protein	DNA
0	5,260	1·0	1·0	1·0
20	5,328	1·0	1·0	1·0
30	4,104	1·2	1·0	1·0
40	3,060	1·4	1·0	1·0
60	1,180	1·9	1·5	1·0
80	932	2·4	1·8	1·3

RNA, Ribonucleic acid; DNA, deoxyribonucleic acid

* Incubation with 5-hydroxyuridine had no effect on survival. The incubation medium was minimal medium (ref. 1) plus casein hydrolysate, 2 mgm./ml. and DL-tryptophan, 0·2 mgm./ml. Ultra-violet exposure was 960 ergs/mm.^{2}.

† Incubation prior to plating on to the mutation assay agar (see Doudney and Haas, ref. 3).

Table 2. COMPARISON OF THE EFFECTS OF 6-AZA URACIL AND CHLORAMPHENICOL ON THE YIELD OF ULTRA-VIOLET INDUCED PROTOTROPHS FROM *Escherichia coli* STRAIN *WP2*

Post-irradiation incubation time† (min.)	Chloramphenicol (20 μgm./ml.)	6-aza uracil (5 mgm./100 ml.)*	
	Prototrophs per 10^8 survivors	Prototrophs per 10^8 survivors	Relative ribonucleic acid concentration
0	5,084	5,084	1·0
10	2,480	2,682	1·0
20	1,628	1,850	1·0
30	852	950	1·0
60	820	990	1·1

* Incubation with 6-aza uracil had no effect on survival. The incubation medium was minimal medium (ref. 1) plus casein hydrolysate, 2 mgm./ml., and DL-tryptophan, 0·2 mgm./ml. Ultra-violet exposure was 960 ergs/mm.^{2}.

† Incubation prior to plating on to the mutation assay agar (see Doudney and Haas, ref. 3).

We have demonstrated a rapid decline in mutation frequency following addition of chloramphenicol to the culture which is complete to a basal level within 20 min.[3]. Table 2 demonstrates that the decline promoted by 6-aza uracil (unlike that promoted by 5-hydroxyuridine) is closely correlated with the decline promoted by chloramphenicol. 6-Aza uracil, like chloramphenicol, blocks protein synthesis. However, unlike chloramphenicol, the analogue presumably blocks protein synthesis through direct blockage of the synthesis of ribonucleic acid. Uridine will reserve the blockage to ribonucleic acid and protein synthesis and will also prevent the decline in mutation frequency promoted by the compound. We thus assume that 6-aza uracil has the capacity to promote 'mutation frequency decline' as does chloramphenicol by interfering with 'mutation stabilization'.

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Activation of Staphylococcal-free Coagulase by Purified Human Prothrombin

Free coagulase[1] is an extracellular protein produced by pathogenic staphylococci[2], which reacts with coagulase activator[3], present in the plasma of certain animal species, to yield an active material capable of clotting any fibrinogen[1]. The active material has been called activated coagulase[4] and has been shown recently, by a study of the kinetics of the reaction between purified free coagulase[5] and an impure preparation of coagulase activator, to be produced during the enzymic degradation of the former by the latter. This work, however, shed no light on the vexed problem of the nature of coagulase activator[3,6–9], owing to the inhomogeneity of the coagulase activator preparation employed.

Through the kindness of Dr. F. Duckert of the Medizinische Universitätsklinik, Zurich, we have been able to repeat some of these experiments, using, as the source of coagulase activator, a highly purified sample of human prothrombin prepared by chromatography on barium sulphate and 'Hyflosupercel' by a slight modification of the method used by Duckert, Koller and Matter[10]. This material contained about 1,000 units of prothrombin and 160 units of coagulase activator per mgm. protein, and was thus enriched between 600 and 700 times (Dr. Duckert, private communication).

Solutions of prothrombin in phosphate buffer (0·07 *M* disodium hydrogen phosphate–potassium dihydrogen phosphate, *p*H 6·8) were incubated at 37° C. with various concentrations of free coagulase and activated coagulase was assayed in the mixtures as already described[4]. The results, which are summarized in Table 1, are essentially similar to those obtained previously[4] and demonstrate the instability of activated coagulase under these conditions. The concentration of activated coagulase produced and the length of time before its exhaustion are directly dependent upon the initial concentration of free coagulase in the mixture. These facts, together with the finding that the exhausted mixtures still contain coagulase activator but no free coagulase, confirm that free coagulase is enzymically degraded by coagulase activator.

Table 1. Formation and Destruction of Activated Coagulase in Mixtures containing a Constant Amount of Purified Human Prothrombin and Various Amounts of Free Coagulase

Values given are for the concentration of activated coagulase (units/ml.)

Incubation time of mixture at 37° C. (hr.)	Concentration of coagulase (units/ml.) added to an equal volume of purified human prothrombin (250 μgm./ml.)			
	25	10	5	2
0	3·3	1·9	1·2	0·5
1	4·3	2·8	1·4	0·6
2	4·0	2·8	1·4	0·6
3	4·0	2·4	1·4	0·5
4	3·8	2·4	0·9	0·3
5	4·3	1·5	0·8	0·25
6	4·0	1·4	0·6	0·23
8	3·0	0·8	0·5	0·17
22	1·5	0·9	0·34	0·08

After incubation for 22 hr. the mixtures were divided into three portions and to (*a*) was added an equal volume of prothrombin 190 μgm./ml., to (*b*) an equal volume of coagulase 25 units/ml. and to (*c*) an equal volume of buffer. They were then incubated for 10 min. and the activated coagulase content measured as before.

a	0·5	0·12	< 0·1	< 0·1
b	3·1	2·7	2·0	2·0
c	0·5	0·13	< 0·1	< 0·1

In view of the highly purified nature of the human prothrombin used as a source of coagulase activator, it seems likely that the two are identical. This suggestion is supported by the observation that the ratio of prothrombin to coagulase activator in normal human plasma is identical with that in the present highly purified preparation of prothrombin.

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CHEMISTRY

Separation of Polyvinyl Chloride and Polyvinyl Acetate by Chromatographic Methods

The material used in this work was known to contain at least two co-polymers. A method of separation was sought which would not require a complex chemical procedure. The separation of high polymers by chromatographic means was carried out by Claesson[1], while separations on columns packed with carbon black were attempted by Landler[2].

It was found that absorption decreased with increased molecular weight. A column of activated charcoal was packed and saturated with methyl *iso*-butyl ketone. The mixture containing the two co-polymers in this solvent was added to the top of the column and washed with the solvent. After a few minutes, the elutant was giving a positive test for chloride. After 1 hr. washing the fractions began to give positive acetate results.

In order to attempt some form of confirmation, a method of separation was devised by paper chromatography.

The mixed co-polymers in solution were spotted on to a strip of Whatman's No. 4 filter paper and air-dried. This strip was then allowed to run at room temperature for 45 min., using once again methyl *iso*-butyl ketone as a solvent. The strip was then air-dried and sprayed with a solution of one part B.D.H. Universal indicator and one part distilled water. The whole strip was then washed in distilled water and dried. The acetate spot remained stationary, while the chloride moved with the solvent front. R_F values were for chloride 0·985 and 0·0 for the acetate. Both spots were eluted, yielding positive tests for acetate and chloride, respectively.

To determine the accuracy of the separation, two pure polymers of acetate and chloride were mixed in the solvent. These were then spotted on to a No. 4 filter paper and run as a control. Identical results were obtained as with the mixed co-polymers.

This method is not suggested as an analytical procedure but as a rapid means of separating mixed polymers.

Further details of this work will be published elsewhere.

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A New Method for working up Processing Mixtures containing Anhydrous Aluminium Chloride

On working up the mixture in order to isolate the products of reactions catalysed by anhydrous aluminium chloride, the first step is usually decomposition with an ice-acid mixture[1]. However, difficulties are often encountered in the separation of the aqueous phase containing the aluminium salts, due to the formation of stable emulsions. This makes the repeated washing of the organic phase necessary to ensure complete extraction of the aluminium salts, a rather tedious operation.

In our experiments we found that a solution of sodium fluoride could be used with advantage at this stage, and also to eliminate interference during later stages. The favourable effect is due to the formation of the complex Na_3AlF_6 which is soluble in water. The advantages of the method may be summarized as follows.

1. The aqueous solution, when it contains sodium aluminium fluoride, is readily and quickly separable from the organic phase, in our experiments, nitrobenzene.

2. When the second step of working up the reaction mixture is steam distillation of an alkaline solution, no separation of the aqueous phase is necessary. Further, as the aqueous phase is already alkaline, no addition of alkali is required to secure the alkaline reaction of the medium.

3. When a neutral solution is wanted during processing, a slightly acidified solution of sodium fluoride can be used. The exact amount of hydrochloric acid necessary can be determined by blank tests on a solution of anhydrous aluminium chloride at the same concentration as the reaction mixture. These blanks are of great importance as the quantity of acid required depends on the quality of the sodium fluoride.

4. Since the method facilitates the working up and analysis of very small quantities, it is particularly suitable for micropreparation and kinetic studies. Although stoichiometrically 6 moles of sodium fluoride are required for each mole of aluminium chloride, we find it best to use at least 7 moles of the reagent.

As an example, part of an unpublished kinetic study will be given here, where a quantitative determination of the ketone was carried out on the mixture obtained by the Fries rearrangement of thymyl acetate in nitrobenzene, in the presence of aluminium chloride.

Preparation of thymyl-methyl ketone. 2·4031 gm. (12·4 m.moles) of 99·14 per cent thymyl acetate was treated with a solution of 4·17 gm. (31·3 m.moles) of anhydrous aluminium chloride (B.D.H.) in nitrobenzene, and the mixture was made up to 20 ml. with nitrobenzene. The mixture was allowed to stand for 5 hr. in a thermostat of 40° C., and then an aliquot of 2 ml. was transferred by pipette into an equal volume of ethanol. This mixture was refluxed for 30 min. with 30 ml. of a solution of sodium fluoride (containing 35 gm. sodium fluoride), 3 ml. of 1 *N* sodium hydroxide and 24 ml. of ethanol. After cooling, the solution was made up at room temperature to 100 ml. with water and allowed to stand overnight in a glass cylinder, 2·5 cm. in diameter, when nitrobenzene separated. A portion of 50 ml. was withdrawn from the clear supernatant with a pipette, treated with 3 ml. of 1 *N* hydrochloric acid and distilled until the temperature of vapour reached 98° C. (approximately 5 min.). The residue was allowed to stand for 2 hr. in an ice box, then the precipitated crystals were filtered through a glass filter, dried at 110° C. for an hour and weighed together with the filter. Thymyl-methyl ketone was then separated from inorganic contaminants by treating the filter with 3 × 5 ml. of hot ethanol. After drying the filter for 20 min. at 110° C., it was again weighed. The difference was 0·0881 gm. The almost white, crystalline product obtained by evaporating the ethanolic solution had a melting point of 122·5–125° C. For $C_{12}H_{16}O_2$, molecular weight 192·25: calculated (per cent): C, 74·97; H, 8·39: found (per cent): C, 74·95; H, 8·07.

The ketone obtained by the classical Rosenmund method[2] was nearly black, m.p. 115–122° C.

The correction for the solubility of the ketone gives a gross yield of 0·092 gm.; thus by the Fries rearrangement a yield of 94·6 per cent was obtained. With suitable modifications the quantity of unconverted ester can also be determined by titration[3].

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PHYSICAL SCIENCES

Calculation of a 'Cosmic Ray Age' for the Iron Meteorite 'Carbo'

The potassium of the iron meteorite 'Carbo', compared with ordinary potassium, is substantially enriched in the isotopes potassium-40 and -41, as shown in the recent isotopic analysis by Voshage and Hintenberger[1]. At least 15 per cent of these isotopes in their sample of 'Carbo' appear to have been produced through the action of cosmic rays. Stoenner and Zähringer[2] found that the concentration of potassium may vary considerably within an iron meteorite. Their analyses were based on the detection of potassium-41 and the assumption that the potassium had the same isotopic composition as terrestrial potassium. If, however, their value of 0·031 p.p.m.

of potassium from one sample is typical of 'Carbo' and is corrected to 0·012 p.p.m. in order to fit the new isotopic analysis, the potassium produced by spallation is at least $4{\cdot}6 \times 10^{-11}$ mole/gm. The total ion beam in the Voshage and Hintenberger analysis indicated that the concentration of potassium-40 alone is even greater than $1{\cdot}8 \times 10^{-12}$ mole/gm. The amount of potassium produced by spallation is probably about 10^{-11} mole/gm. This figure is quite compatible with that of $1{\cdot}1 \times 10^{-10}$ mole/gm. for the helium-3 content[2] because the cross-section for the formation of potassium, including the contribution from argon-39 and calcium-41, seems to be[3] about 40 mb., and the measured cross-section for the production of helium-3 (with hydrogen-3) by means of 3 BeV. protons on iron is approximately[4] 340 mb. The neon also formed by spallation has a concentration[5] of $5{\cdot}8 \times 10^{-12}$ mole/gm., which is comparable with that indicated for the potassium.

Radioactive species formed by spallation have been used to estimate the production rate of stable isotopes by cosmic rays. Radiation ages have been calculated in this way for meteorites from their helium-3 and argon-38 contents[6]. The combination of stable isotopes of potassium with the relatively long-lived potassium-40 may also be used to calculate a 'cosmic ray age', Δt in the following equation:

$$\frac{1 - e^{-\lambda \Delta t}}{\Delta t} = \frac{\lambda K^{4.0}_m (\sigma_{39} - R\sigma_{41})}{\sigma_{40}(K^{3.9}_m - RK^{4.1}_m)}$$

The relative abundances of the potassium isotopes used are $K^{3.9}_m = 0{\cdot}795$, $K^{4.0}_m = 0{\cdot}048$, and $K^{4.1}_m = 0{\cdot}157$, as reported by Voshage and Hintenberger[1] for the meteorite 'Carbo'. The total decay constant, λ, is taken as $0{\cdot}529 \times 10^{-9}$ yr.$^{-1}$. R is the ratio of K^{39}/K^{40} in ordinary potassium.

In addition to the usual assumption regarding a constant cosmic ray flux, some knowledge of the cross-sections for the formation of the potassium isotopes is required. The cross-section versus mass curves for argon formed by high-energy protons on iron and copper are well defined experimentally (refs. 3 and 4 and Bieri, R. H., personal communication). The curves are similar and are skewed towards the side of the neutron-rich isotopes. The known isotopes of potassium suggest that the spallation curve of this element is similarly asymmetrical and that the production cross-sections for potassium-40 and -41 are rather large and approximately the same.

Barr[3] has estimated the approximate production cross-sections for the isotopes potassium-39, -40 and -41 for 5·7 BeV. protons on copper. These cross-sections are 5·2, 9·4 and 9·2 mb., respectively. He inferred them from his measurements of the yields of more than fifty radioactive isotopes produced by the spallation of copper. The observed cross-sections for potassium-42 and -43 were 5·4 and 1·1 mb., respectively. Other spallation products such as argon-39 and calcium-41 contribute significantly to the formation of potassium. The cross-sections for the formation of potassium estimated from Barr's work then become $\sigma_{39} = 14{\cdot}8$, $\sigma_{40} = 9{\cdot}4$, and $\sigma_{41} = 14{\cdot}7$ mb.

The radiation age calculated from the preceding values is $0{\cdot}6_9 \times 10^9$ yr. It is obvious in the above equation that the value for σ_{39} is comparatively insignificant. This figure may be incorrect by a factor of 2 without influencing the value of the right side of the equation by more than 10 per cent. The relative values for σ_{40} and σ_{41} are important. A difference of even 20 per cent in their ratio affects the radiation age by 1×10^9 years. This seems to be approximately the uncertainty in this radiation age of 'Carbo'; but the relative ages of iron meteorites may be determined with much greater precision. For the radiation age from the potassium to be $4{\cdot}6 \times 10^9$ years, or the same as the lead–lead age[7,8] and the rubidium–strontium age[9,10] of stone meteorites, σ_{41} would have to be about one-half the value for σ_{40}. It should be noted that contamination will have a negligible effect on the radiation age as long as the observed abundance of potassium-40 is much greater than the potassium-40 in ordinary potassium.

The cosmic ray age calculated here for 'Carbo' is essentially the same as its estimated cosmic ray helium age of $0{\cdot}85 \times 10^9$ years[11]. The potassium–argon ages of several stone meteorites are also quite similar. The chondrites 'Kunashak' (grey variety) and 'Pervomaiskii Poselok' (grey variety) have ages of $0{\cdot}70 \times 10^9$ and $0{\cdot}64 \times 10^9$ years, respectively[12]. The two shergotites 'Padvarninka' and 'Shergotty' have ages of $1{\cdot}0 \times 10^9$ years[12] and $0{\cdot}56 \times 10^9$ years[13], respectively. It seems that the stone meteorites belong to two groups, one with radiogenic helium ages of 4×10^9 years, the other with ages of about $0{\cdot}5 \times 10^9$ to 1×10^9 years[14]. Helium probably has been lost from the meteorites of the latter group. The potassium–argon ages for the same meteorites clearly indicate some loss of argon[14].

The accuracy of the cosmic ray age calculated from the potassium produced by spallation depends principally upon how well the ratio of the formation cross-sections for potassium-40 and -41 is known and the constancy of the cosmic ray flux. Nevertheless, this age of $0{\cdot}6_9 \times 10^9$ years agrees remarkably well with independent age determinations for this meteorite and for other meteorites. Evidence is rapidly accumulating for the break-up of solid bodies and for the presumably related heating of at least some of the meteorites between $0{\cdot}5$ to $1{\cdot}0 \times 10^9$ years ago. The comparison of potassium analyses from other iron meteorites may help to answer the question of whether these processes occurred throughout approximately half a thousand million years or during a much shorter interval.

I wish to thank Dr. R. H. Bieri and Dr. J. Geiss of this Institute for many discussions. This study was supported by a grant from the U.S. National Science Foundation.

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May 16.

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Refraction of Very High Frequency Radio Signals at Ionospheric Heights

People engaged in radio tracking of space vehicles are well aware of the fact that the Earth's atmosphere may cause serious refractive errors in the elevation angle determination. It is also generally accepted that refractive errors rapidly decrease with an increase in the elevation angle, and become virtually negligible above 10 or 15 degrees. In the case of radio astronomy, this is quite true. However, in the case of space-vehicles, which travel in the immediate vicinity of the Earth, this is not the case. The refractive errors due to the troposphere rapidly decrease with the elevation angle, while those due to the ionosphere initially increase with the elevation angle, and then gradually fall off. This behaviour of ionospheric refraction is a necessary consequence of the spherical geometry. The value of the elevation angle at which the maximum ionospheric refractive error occurs lies typically between 100 and 200 milliradians. The exact expressions are rather involved, but it can be shown that the value of this angle is roughly proportional to the square root of the height of the layer. The maximum value of the ionospheric refractive error is about 10–15 per cent higher than its value for a tangentially departing ray.

Fig. 1 shows a plot of the elevation angle error δ for realistic models of the ionosphere and troposphere. The tropospheric calculations were based on radiosonde data. The ionospheric calculations were based on a model of electron density profile which was parabolic below the region of the maximum density and was represented by the hyperbolic secant above the maximum. The constants of the hyperbolic secant were adjusted so that the profile and its derivative were continuous everywhere, and the total electron content above the maximum was three times as large as below it. This is in accord with experimental data based on Faraday rotation measurements[1]. Details of the computational techniques are described elsewhere[2].

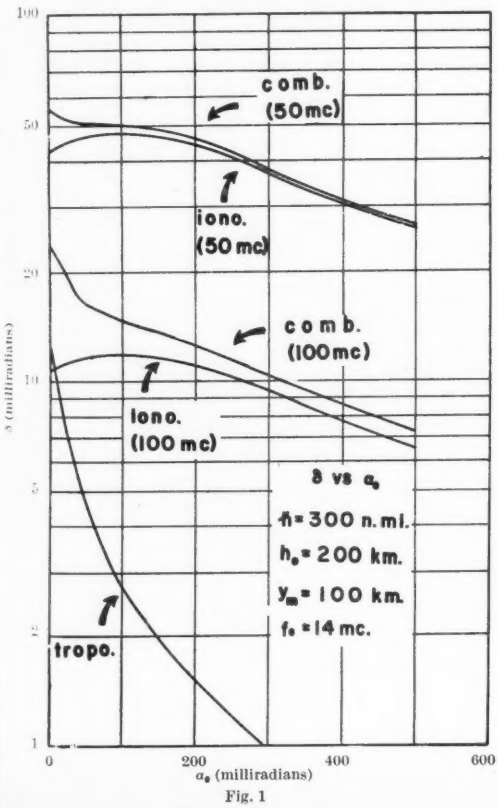

Fig. 1

For the purpose of the accompanying illustration, the ionospheric constants were adjusted as follows: height of the base 200 km., half thickness 100 km., critical frequency 14 mc., signal frequencies 50 and 100 mc. The target height for which the refractive errors were computed was 300 nautical miles.

Examination of Fig. 1 shows that, at very low angles of elevation, α_0, the tropospheric refraction contributes appreciably to the refractive error while, at higher angles, the ionospheric factors predominate. The peculiar behaviour of the ionospheric refraction manifests itself by the presence of the shoulder which is especially prominent at 50 mc., and also by the fact that the refractive error decreases more slowly with the elevation angle than might have been expected from the study of the refraction of radio stars.

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Near Infra-Red System of Nitrogen

In the course of studying the molecular spectrum of nitrogen under various excitation conditions, Carroll and Sayers[1] discovered a new triplet transition in the near infra-red. Only one band was observed as the spectral region of interest was dominated by bands of the first positive system. A spectrogram of the new band was given together with measurements of the four strongest heads at 8265·5, 8283·8, 8293·3 and 8310·6 A. The structure of the band was obviously complex, and it was suggested by Carroll and Sayers that the transition might be $^3\Pi - {}^3\Sigma$.

More recently Kistiakowsky and Warneck[2] have reported bands of nitrogen in the infra-red, and these observations have been extended by LeBlanc, Tanaka and Jursa[3], who studied the emission from afterglows in argon–nitrogen mixtures at low temperature. They also made a preliminary vibrational analysis and showed that the lower state was most probably $B\ ^3.\ g$.

There is no doubt that the new system is the same transition as that reported by Carroll and Sayers. This is proved by (*a*) the close similarity in structure between the 8265·5 A. band on Carroll and Sayers's spectrogram and the bands in the spectrogram given by LeBlanc, Tanaka and Jursa; and (*b*) the agreement between the measurements of corresponding heads in the 8265·5 A. band and the $(n + 1) - 1$ band of LeBlanc, Tanaka and Jursa.

As the new system is of both theoretical[4] and astrophysical[5] interest the 8265·5 A. band has recently been investigated under large dispersion. It was

photographed in the second order of the 21-ft. grating in the Physics Department of University College, Dublin, and despite the weakness of the band and the presence of the first positive system, a rotational analysis proved possible. Three components were found, each consisting of a fairly strong P, Q and R branch together with a number of weaker satellite branches. A detailed examination of the results shows unambiguously that the upper state is of species $^3\Sigma^-_u$. A preliminary value of B_{n+1} determined from the Q branches alone gives $1{\cdot}38_0$ cm.$^{-1}$. The analysis also verified beyond doubt that the lower state of the 8265·5 A. band is the level of $v = 1$ of $B^3\Delta_g$. This is shown by the excellent agreement between the combination differences derived from the present analysis and those formed from the data on the 1–0 band of the first positive system[6].

The vibrational numbering of the levels in the $^3\Sigma^-_u$ state is not known with certainty at present. However, one can say that the $v = 0$ level cannot lie above about 71,700 cm.$^{-1}$ and that it very probably lies within a few vibrational quanta of this value. Now Mulliken[4], in his theoretical work on nitrogen, has predicted that a $^3\Sigma^-_u$ state, with a B value of approximately 1·47 cm.$^{-1}$, should occur at about 70,700 cm.$^{-1}$. It is seen that the results of the present work are in satisfactory agreement with Mulliken's theoretical predictions.

A full account of the above work will be published elsewhere in the near future.

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Luminous Spots on Electrodes in Insulating Oil Gaps

In 1955 we reported the observation of luminous spots on electrodes in transformer oil[1]. The spots were detected by a photographic plate in the oil between the electrodes with application of a.c. and d.c. voltage stresses for 2–30 min. The oil was usually degassed but not filtered. The luminous spots occurred at random on the surface of a plane electrode and were more concentrated at sharp edges. One of the electrode systems used was an American Society for Testing Materials oil-breakdown test-cup. The threshold average electric stress seemed to be of the order of 50 kV./cm. minimum. At the time of those experiments it was not known whether these luminous spots were due to discharges in tiny bubbles or to another cause.

Since those preliminary experiments, more refined and efficient techniques have been used in the investigation of these luminous spots, whereby the electrodes are observed face on through a glass window coated with transparent semiconducting tin oxide. Microscopic examination has shown that, while bubbles do occur sometimes at high stresses under low hydrostatic pressures, or with fibres present, bubbles are not responsible for the luminous spots observed on electrodes in well-filtered, degassed oil. The luminous spots have been shown to occur only at the negative electrode with d.c. stresses and are therefore attributed to fluorescence of the oil molecules excited by field-emitted electrons from points of high localized electric stress on the electrodes. They have been detected by 10-min. exposures with Ansco Super Hypan Film (*ASA* 500) in a camera having an *f*2 lens opening at a distance of about 5 in. It is believed that these luminous spots are similar to the luminosity reported seen by Darveniza[2] at 600 kV./cm., but detected here at much lower average electric stresses. The threshold voltage stress seems to be of the order of 50–250 kV./cm., depending on the degree of polish of the electrodes and filtering of the oil. The local electric stress is very likely 10 or more times higher.

M. Wachtel (Westinghouse Research Laboratories, private communication) and Llewellyn-Jones[3] have reported electron field emission into a vacuum or low-pressure gas at average electric stresses of the same order as used here.

The occurrence of luminous spots is not significantly affected by applied hydrostatic pressure from 10 mm. mercury to 2 atmospheres. They also occur with a.c. voltages between glass surfaces, indicating that field emission occurs from glass surfaces. The luminosity is not affected by an efficient additive, benzil, reported by Basseches and McLean[4] to prevent gassing.

It is believed that observation of these luminous spots assists in explaining the statistical effect of electrode area (and volume) on breakdown, particularly in commercial tests, and the dependence of long time a.c. electric strength on time of voltage application. It also suggests the origin of the development of gas (hydrogen) in stressed oils, since the electrons exciting fluorescence (requiring about 3 eV.) may also have or gain by acceleration sufficient energy to decompose the hydrocarbon oil molecules (requiring about 4 eV.).

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Compaction of Briquettes

When a powder is compacted by a simple application of pressure, the density and strength of the compact so formed (measured after the pressure has been released) are determined by the pressure used, but ultimately they approach limiting values which are not exceeded by further increasing the pressure. The limiting density of the compact falls short of the density of the material of the powder by an appreciable margin, say 4–20 per cent, depending on the material used (Fig. 1).

This failure to achieve complete compaction arises in two ways. First, as the briquetting pressure is applied it is opposed by forces set up in the powder

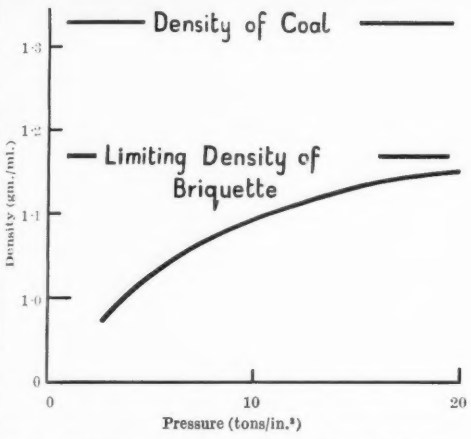
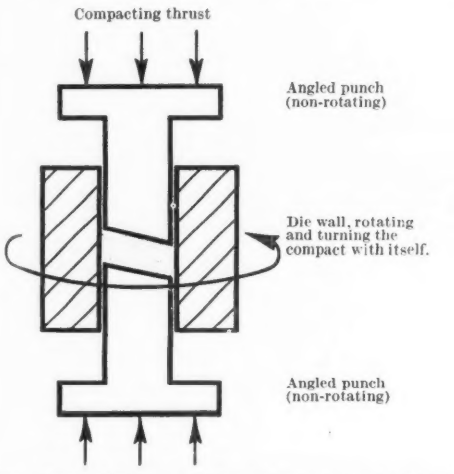


Fig. 1. Betteshanger coal: relationship between briquetting pressure and density of briquette

and upon the walls of the mould, which resist the movement of the particles and which resist the deformation of individual particles; these forces prevent intimate contact between the particle surfaces. Secondly, as the external pressure is removed, the deformed particles recover their shape elastically, in part at least, and the compact expands and the voids within it increase. A large elastic recovery is associated with a weak compact.

It has been found that if the powder compact, while still under load, is subjected to shear strain, (as for example in a rotary shearbox as sketched in Fig. 2) there is a further compaction without any further increase in pressure being required. Also, the elastic recovery of the compact when constraints are removed is reduced. The compact made in this way is stronger than one made by simple pressing at the same pressure, and may possess greater density and strength than the limiting values obtained by simple pressing. Whether the compact is made by simple pressing or by introducing additional shear


Compacting thrust
Angled punch (non-rotating)
Die wall, rotating and turning the compact with itself.
Angled punch (non-rotating)

Surface of contact between punches and compact are lubricated to allow the compact to rotate within the die wall

Fig. 2. Action of a rotary shearbox

strain under load, the strengths and densities are still related by the same single curve. The gain in strength may be substantial, and with coal powders a five-fold increase has been attained. The full benefit is obtained only if the shear strain is introduced under maximum load (Fig. 3).

The response to the introduction of additional shear strain under load varies with the material. In a material such as 'Plasticine', which deforms plastically very readily and which has negligible elastic recovery, the process offers no advantage. Natural graphite powder also compacts readily, and reduces to a compact of about 4 per cent porosity by simple pressing; here again there is little advantage in applying extra shear strain, which may do more harm by disrupting the briquette than good by compacting it. At the other extreme, anthracite powder, which shows an elastic recovery of 30 per cent while still in the die in which it has been pressed, forms no compact at all, with or without extra shear strain. The advantage of the process is found with materials lying between these extremes. The coal, the properties of which are illustrated in Fig. 3, is an example; the introduction of extra shear strain improves the compaction of the final briquette by about 10 per cent porosity, and the strength by a factor of 3–5.

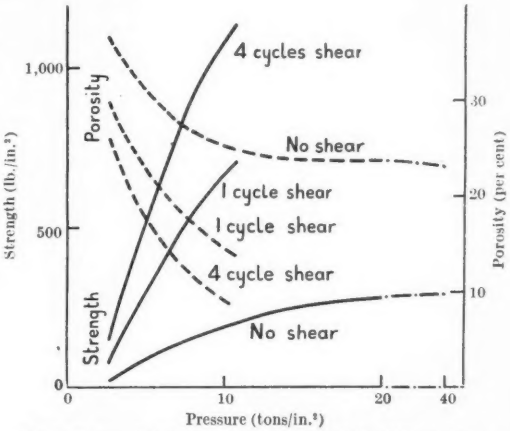


Fig. 3. Sherwood coal: relationship between briquetting pressure, shear strain, strength and porosity (shear strain introduced in cycles of amplitude 8°)

The adhesion of particles in these non-metallic compacts is not yet fully understood, nor is the action understood whereby shear strain improves the adhesion. The fact that a single strength–density relationship applies to all compacts made from a given powder, with or without extra shear, suggests that no new mechanism of adhesion is introduced by shearing.

The work described in this paper was carried out as part of the research programme of the Scientific Department of the National Coal Board and is published by permission of the Director-General of Research.

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D. C. Rhys Jones
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National Coal Board,
Coal Research Establishment,
Stoke Orchard,
Cheltenham. May 26.

BIOLOGY

Association between Colour of the Iris of the Eye and Reaction to Dental Pain

An association has been found to exist, in Australians of European stock, between the colour of the eyes and the reaction to pain resulting from dental cavity preparation.

At the present stage of this study, examination has been made of 403 consecutive subjects whose teeth were being prepared for filling, the cavities being cut by means of the Borden high-speed air-rotor apparatus. Their ages ranged from three years to more than fifty years.

The pain reaction of each subject was assessed, four classes being used: subjects that showed (*a*) no pain reaction during the preparation of the cavity, (*b*) a slight reaction, (*c*) a marked reaction and (*d*) those whose reaction was so great as to require the injection of a local analgesic. After having recorded the pain reaction of a subject, the colour of the iris was observed, nine categories, ranging from blue to dark brown, being recorded. The pain-reaction classes were given arbitrary values of 0–3, and the colours of the iris, values of 1–9.

The association between these factors is highly significant, but, of course, is considered to be due to their joint association with other factors. The accompanying graph (Fig. 1) of mean values displays the association between pain reaction and colour of iris.

Each point of the graph is based on more than 40 observations, with the exception of the last three, for only 11 subjects were seen with light brown eyes, 23 with brown and 28 whose irises were dark brown.

Judgement of the reaction to pain is based on 12 months use of this new apparatus (Borden high-speed air-rotor), and on more than twenty years clinical experience; nevertheless, it is acknowledged that both types of observation are open to criticism owing to their subjective nature. However, a test to establish the reproducibility of the results was satisfactory, for out of 136 subjects that were re-assessed between one and four weeks after the original examination, the same values were obtained for the colour of the eyes in 115 cases, and for the pain reaction in 114 subjects. Both for colour of iris and for pain reaction, the mean of the discrepancies between each pair of results was non-significant; the mean discrepancies were, pain reaction 0·02, iris colour 0·04.

Approximately 13 per cent of the total number of subjects required the injection of a local analgesic for cavity preparation, a similar percentage being found in the group of subjects formed by adding the results of those whose eyes were greyish-green, green or hazel. However, this aid was not required by any blue-eyed subjects, and was used for only 2 per cent of those with greyish-blue or greenish-grey eyes; but it was required by 30 per cent of the subjects with light brown or brown eyes, and by more than 53 per cent of those whose eyes were dark brown.

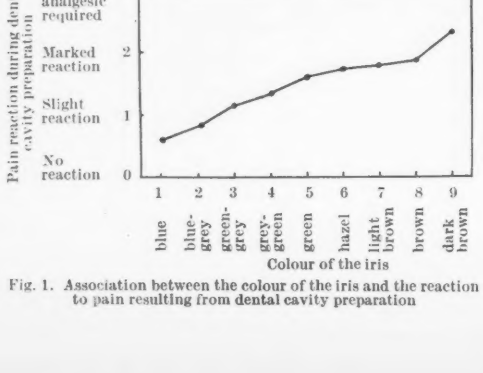

Fig. 1. Association between the colour of the iris and the reaction to pain resulting from dental cavity preparation

My thanks are due to Sir Arthur Amies, and to the University of Melbourne Research Fund.

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Development of the Aplacophorous Mollusc *Neomenia carinata* Tullberg

Present-day authorities agree that, within the Mollusca, the chitons (or Polyplacophora) are closely related to the solenogastres (or Aplacophora). An important item influencing this view is the description, by Pruvot[1], of the development of seven overlapping, dorsal, plate-like spicules in the metamorphosing larva of the solenogastre, *Nematomenia banyulensis*. The appearance of these spicules has been considered to be a reminiscence of a chiton-like ancestor and, no doubt, has influenced many authors in coming to the conclusion that the solenogastres are degenerate chitons. Pruvot's description was based on observations on a single larva, but nonetheless the figure he gave of this developmental stage has been widely reproduced in general works.

The purpose of the present communication is to describe some observations on the development of *Neomenia carinata* Tullberg 1875; together with the work of Baba[2] on *Epimenia verrucosa*, they show clearly that, while the larva of *Nematomenia* may develop overlapping dorsal plates in the manner described by Pruvot, this is by no means the rule in the Aplacophora.

The embryos of *Neomenia carinata* hatch three days after oviposition (at 10° C.) as trochophores with the blastopore still open abapically, but with no stomodaeum yet developed (Fig. 1*A*). These larvæ swim over the bottom of the culture vessel, propelled by the strong cilia of the prototroch. As the larvæ proceed, they spiral in the same direction as the metachronal waves travel around the prototroch (clockwise when viewed from the anterior). At 7–8 days metamorphosis begins; a caudal bud begins to protrude through what was formerly the blastopore (Fig. 1*B*). The tip of this bud bears a minute pore, the anus, and is ciliated. The rest of the bud, as it grows out, is unciliated but bears large numbers of pointed spicules (Fig. 1*C*). The 'trochophore' part of the larva remains ciliated, but becomes reduced in size, while the prototroch and apical tuft degenerate. The caudal bud comes to form by far the greater proportion of the larva (Fig. 1*D*). The last remains of the ciliated trochophore-mass are ingested through the mouth as the larva completes metamorphosis (Fig. 1*E* and *F*) and abandons pelagic life. At no time is there any trace of segmentation, nor of any dorsal shell-plates. When metamorphosis is complete the external surface of the body (except perhaps for the pedal groove) is unciliated, and the form is like that of the adult *Neomenia*.

This description is based on observations on large numbers of larvæ of *Neomenia carinata* reared through metamorphosis in the laboratory, and the

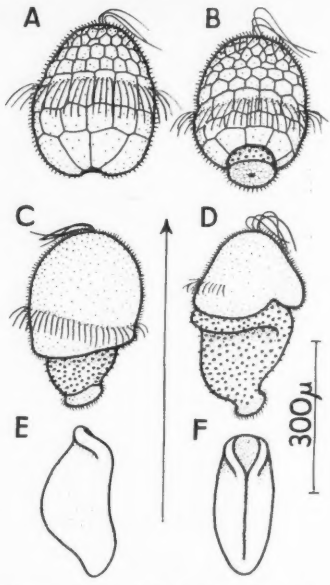

Fig. 1. Metamorphosis of *Neomenia carinata* (camera lucida drawings of live larvæ). *A*, Trochophore at 3 days; *B*, trochophore at 9 days, ventral aspect; *C*, trochophore at 10 days, right lateral aspect; *D*, trochophore at 11 days, right lateral aspect; *E*, newly metamorphosed stage (12 days), right lateral aspect; *F*, the same, ventral aspect. In *E* and *F* the spicules are not illustrated. The arrow shows the antero-posterior axis of the animals

results so far obtained plainly show the need for a re-investigation of the development of *Nematomenia*. At present, the indications are that the nearest relatives of the Aplacophora within the Mollusca may be found in the primitive Lamellibranchia rather than in the Polyplacophora. The resemblances in development between the solenogastres and members of the Brachiopoda, Archiannelida and Nemertea (to which various authors have directed attention) are probably without profound significance. The work on *Neomenia* is being continued and is financed by a grant from the Leverhulme Trust.

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Dagger Nematodes associated with a Clover Sickness

Dagger nematodes (*Xiphinema* spp.) are now recognized as important crop pests in many North American states[1–3] and occur widely in tropical countries[4,5] in close association with plant roots. Because of their migratory ectoparasitic habit they are seldom observed feeding on the host plant, and where they appear to be associated with crop damage pathogenicity is difficult to prove.

Examination in early February of 'sickly' white clover (*Trifolium repens* L.) plants from a clover ley near Crewkerne, Somerset, showed no pathogenic organism, but large numbers of dagger nematodes were recovered from the soil around the roots. The roots themselves bore minute lesions compatible with nematode feeding, and many young rootlets were brown and shrivelled at the tip. The field, a sandy loam, had been sown to grass and clover leys in seven out of the past ten years and had a similar early history.

The area was again sampled at the end of April, by which time the clover was dying off in patches. Many dagger nematodes were again recovered, but fungal damage was also evident and small sclerotia, believed to be those of *Sclerotinia trifoliorum* Erikss., were seen; the stem eelworm *Ditylenchus dipsaci* Kühn also occurred in numbers sufficient to constitute a possible cause of disease.

The exact role of dagger nematodes in this complex is thus uncertain; this is the first record of the genus *Xiphinema* in Great Britain, and observations and measurements suggest that the specimens recovered represent a new species, which will be described elsewhere.

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Pollen of *Acacia* from Tufaceous Limestone near Udaipur

I have undertaken the investigation of fossil microflora from a tufaceous limestone near Udaipur. This fossiliferous locality is about three-quarters of a mile north-west of the tenth milestone on the Udaipur–Gogunda Road. It was first described by Murty[1], who had suggested a tertiary age to these beds.

A few pieces of fossil were macerated with Schultz's solution and clear dehydrated mounts were prepared by passing the material through various grades of alcohol and mounting in Canada balsam. Some of the preparations were stained with safranin. The

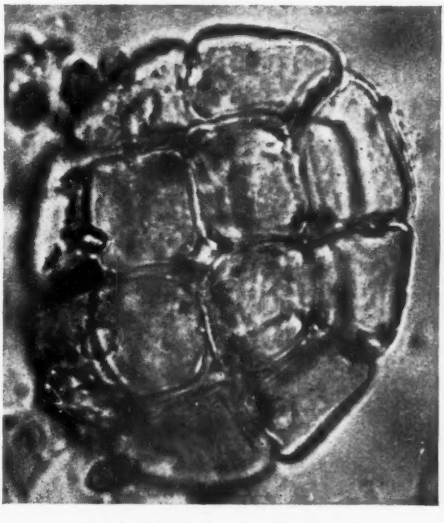

Fig. 1. Fossil *Acacia* pollen grain. (× 845)

slides so prepared showed many angiospermic pollen grains, some of which belong to the Leguminosae and the Gramineae. Also a few pteridophytic spores were observed.

One well-preserved pollen grain resembles very closely that of *Acacia longifolia*. It is a smooth compound 16-celled grain; eight cells are centrally placed, forming a sort of cubical block with the others arranged in a rectangular fashion. The central group is surrounded by eight peripheral cells all in a plane at right angles to, and bisecting, the central group. The peripheral cells are so placed that their eight contacts with each other are alternately opposite and midway between the four contacts of the central group. The group as a whole is flattened, with a more or less rounded outline, and the intersecting lines between the individual grains cross each other at right angles.

The exine is thick and its corners are rounded. The individual grains measure about 24·5μ in diameter and the whole compound grain is 69·5μ in diameter.

It is significant to note that fossil pollen grains of the *Acacia* type have been recently described from the Victorian Tertiary deposits, Australia, by Cookson[2].

I thank Dr. Chitley for her guidance in this work.

T. Trivedi

Government College of Science,
Nagpur.

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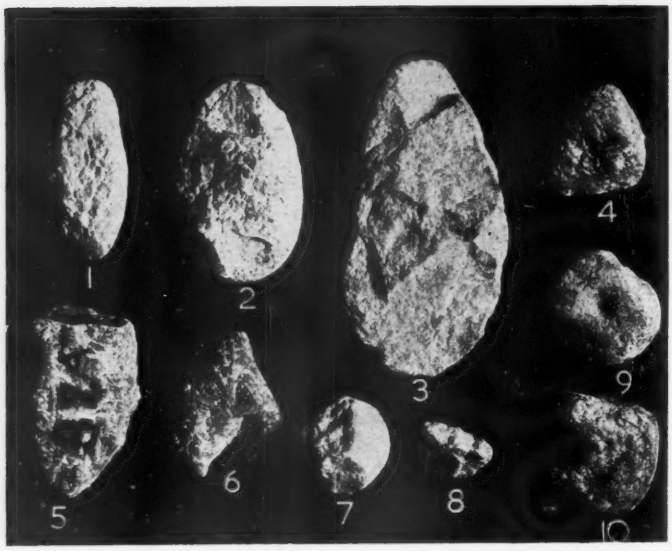

Table 1

Description	Dimensions	No.
Polished hand axes, Fig. 1	Approx. 12 × 6 × 2½ cm.	5
Fragments	Average width: 6 cm.	10
Well-formed bifaced hand axe, Fig. 2	14 × 9½ × 5 cm.	1
Unifaced hand axe, Fig. 3	23 × 12½ × 4½ cm.	1
Polished cleaver-like stone, Fig. 4	7½ × 7 × 3½ cm.	1
'Points', Fig. 5	Approx. 13 × 9 × 2½ cm.	2
Tanged unifaced blade, Fig. 6	11 × 9 × 2 cm.	1
Hand-held polishing or grinding stones, Fig. 7	Approx. 7 × 6 × 6 cm.	3
Bifacial discoid stones (scrapers ?), Fig. 8	Approx. 4 × 6 × 2 cm.	2
Anvil stones indented both surfaces, Fig. 9	Approx. 9 × 7 × 4 cm.	4
Balls	5–8 cm. dia.	15
Eccentrically perforated stone, Fig. 10	Width, 8 cm.; perf., 2 cm.	1
Fractured stone cylinder	6 cm. dia.	1

ARCHÆOLOGY

Stone Implements from Western Nigeria

Recently a number of stone implements have been uncovered by labourers in sand quarries at Green Springs near Ibadan, Western Nigeria. These implements are associated with deposits of river sand and clay. The workmen wash the sand, discarding the clay and stones, usually placing the latter in heaps or scattering them about the ground. Thus it has not been possible to determine the level at which they were lying before excavation. Generally, however, the layers containing stone are between one and seven feet below the main surface-level.

Table 1 lists the definite artefacts found. The material is mainly quartz from the basement complex.

Polished stone axes are common in Nigeria, where they are often used as protective charms against thieves and thunder, in the belief that they are fallen thunderbolts. Flaked and tanged implements, however, have not previously been recorded from the Western Region of Nigeria, although flaked implements which have been compared to the Chelles–Le Moustier epoch in Europe are found in Northern Nigeria[1], and other flaked implements have been reported from the Eastern Region and the Cameroons[2]. Typologically, the Green Springs implements fall into two groups: (*a*) neolithic types, represented by stone balls, polished axes, anvils, and grinding stones; and (*b*) palæolithic types, represented by the points, the flaked axes and the tanged blade. The latter are suggestive of the Aterian cultures of North Africa[3,4].

We are of the opinion that systematic excavation in the area may be of advantage to pre-history. We wish to acknowledge the kind help of Mr. R. Hockey, geologist, Geological Survey Department, Federal Government of Nigeria.

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March 31.

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FORTHCOMING EVENTS

Monday, August 31—Saturday, September 5

10TH CONGRESS OF THE INTERNATIONAL ASTRONAUTICAL FEDERATION (at Church House, Westminster, London, S.W.1).

Wednesday, September 2—Wednesday, September 9

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at York).—Annual Meeting.

Wednesday, September 2

At 8 p.m.—Sir James Gray, C.B.E., M.C., F.R.S.: "The Proper Study of Mankind is Man" (Presidential Address).

Thursday, September 3

At 10 a.m.—Prof. L. F. Bates, F.R.S.: "The Visualization of Magnetic Processes" (Presidential Address, Section A).

At 10 a.m.—Prof. M. Stacey, F.R.S.: "Medical Applications of Complex Carbohydrates" (Presidential Address, Section B).

At 10 a.m.—Dr. L. Harrison Matthews, F.R.S.: "Man and the World Fauna" (Presidential Address, Section D).

At 10 a.m.—The late Dr. W. R. G. Atkins, F.R.S.: "Plants on Land and in the Oceans" (Presidential Address, Section K, read by Dr. C. P. Spencer).

At 10 a.m.—Dr. H. G. Sanders: "Balance in British Farming" (Presidential Address, Section M).

At 11.15 a.m.—Mr. W. R. Day: "The Influence of Pathogenic Factors within the Rooting Space on the Development of Even-aged Plantations" (Chairman's Address, Section K*).

At 11.30 a.m.—Sir Ewart Smith, F.R.S.: "The Critical Importance of Communication and Transport" (Presidential Address, Section G).

At 2.30 p.m.—The Countess of Albemarle: "Living with Science" (Presidential Address, Section X).

Friday, September 4

At 10 a.m.—Prof. K. C. Edwards: "Trends in Urban Expansion" (Presidential Address, Section E).

At 10 a.m.—Prof. John Jewkes: "How Much Science?" (Presidential Address, Section F).

At 10 a.m.—Sir James J. Robertson: "What Are Our Schools For?" (Presidential Address, Section L).

At 11.30 a.m.—Prof. Magdalen Vernon: "Perception, Attention and Consciousness" (Presidential Address, Section J).

At 8 p.m.—Prof. M. Swann: "The Unseen Pattern of Growth" (Evening Discourse).

Sunday, September 6

At 10.30 a.m.—Official Service at York Minster. Preacher: The Most Reverend The Lord Archbishop of York.

Monday, September 7

At 10 a.m.—Prof. O. M. B. Bulman, F.R.S.: "Recent Developments and Trends in Palæontology" (Presidential Address, Section C).

At 10 a.m.—Prof. Ian A. Richmond: "The Nature and Scope of Archæology" (Presidential Address, Section H).

At 10 a.m.—Prof. A. Hemingway: "Artificial Organs—Biological Applications" (Presidential Address, Section I).

At 8 p.m.—Sir William Hildred: "International Air Transport Problems" (Evening Discourse).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ANALYST (qualified for general inorganic analysis) in the Houldsworth School of Applied Science, mainly for work on silicates—The Registrar, The University, Leeds 2 (August 31).

LECTURER IN MATHEMATICS; LECTURERS (2) IN GEOGRAPHY; and LECTURERS (2) IN EDUCATION at Palmerston North University College, (Victoria University of Wellington), New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, August 31).

LECTURER (preferably with experience in solid-state or low-temperature physics or ultrasonics) IN PHYSICS—The Registrar, Queen Mary College, Mile End Road, London, E.1 (August 31).

ASSISTANT LECTURER (preferably with interests in plant physiology and plant ecology) IN BOTANY—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey (September 1).

SENIOR LECTURER AND DIRECTOR (with high academic qualifications and experience of high-speed digital computers) OF THE SUB-DEPARTMENT OF COMPUTATION—The Secretary and Registrar, The University, Southampton (September 1).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF AGRICULTURAL ECONOMICS—The Registrar, University College of Wales, Aberystwyth (September 5).

LABORATORY STEWARD IN THE DEPARTMENT OF BOTANY—The Registrar, University College, Singleton Park, Swansea (September 8).

LECTURER IN ZOOLOGY in the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 11).

ASSISTANT LECTURER IN DAIRYING—The Registrar, University College of Wales, Aberystwyth (September 12).

LECTURER IN PURE MATHEMATICS; SENIOR TUTORS (2) IN PURE MATHEMATICS; and a SENIOR LECTURER IN PHYSICAL METALLURGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 19).

LECTURERS (2) IN ASTRONOMY in St. Salvator's College, University of St. Andrews—Joint Clerk to the University Court, College Gate, St. Andrews (September 19).

LECTURER IN EDUCATION at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 20).

SENIOR TUTOR-DEMONSTRATORS (2) IN ZOOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 26).

LECTURER IN MATHEMATICS at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

LECTURER IN GEOGRAPHY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 1).

MYCOLOGIST (with a good honours degree in botany, with mycology as a special subject, a knowledge of the more fundamental aspects of animal and human mycoses, and preferably a knowledge of Latin and other languages) at the Commonwealth Mycological Institute, Kew—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (November 30).

JUNIOR PLANT BREEDER (male, with a good honours degree in botany with postgraduate experience in the technique of plant improvement) at the West African Cocoa Research Institute (serving initially at Tafo, Ghana), to carry out research on plant-breeding problems relating to cocoa—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.197/200/08/T.

LECTURER IN PHYSICS, and an ASSISTANT LECTURER IN PHYSICS (Grade "B")—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

SENIOR LECTURER IN ZOOLOGY—The Registrar, Bradford Institute of Technology, Bradford 7.

TECHNICIAN IN THE ZOOLOGY DEPARTMENT—The Secretary, Royal Holloway College, Englefield Green, Surrey.

REPORTS and other PUBLICATIONS

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Great Britain and Ireland

Abstracts of Dissertations approved for the Ph.D., M.Sc., and M.Litt. Degrees in the University of Cambridge during the Academical Year 1956–57. Pp. xviii+267. Titles of Dissertations approved for the Ph.D., M.Sc., and M.Litt. Degrees in the University of Cambridge during the Academical Year 1957–1958. Pp. iv+25. (Cambridge: Board of Research Studies, The University, 1959.) [144

British Electrical and Allied Industries Research Association Technical Report E/T65: The Low Temperature Liquid Phase Oxidation of Hydrocarbons: a Literature Survey. By Prof. Frank Morton. Pp. 33+8 figures. 21*s*. Technical Report L/T365: Ultra-High Frequency Gas Breakdown between Rogowski Electrodes. By W. A. Prowse and J. L. Clark. Pp. 15+25 figures. 18*s*. Technical Report L/T368: Effects of Coulomb Forces on the Conduction Properties of Semi-Conductors. By S. Doniach. Pp. 37. 18*s*. Technical Report L/T371: The Calculation of Insager's Reaction Field for a Particular Model. By B. V. Paranjape. Pp. 8+2 figures. 7*s*. 6*d*. Technical Report Z/T117: Evolution of Extra-Galactic Nebulae and the Origin of Metagalactic Radio Noise. By Dr. C. E. R. Bruce. Pp. 7. 9*s*. (Leatherhead: British Electrical and Allied Industries Research Association, 1955, 1957 and 1958.) [144

Polish Cultural Institute, London. Selective Quarterly Guide to Polish Periodical Literature, Vol. 4, 1, 1959. Pp. i+76. (London: Polish Cultural Institute, 1959.) [144

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Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act 1954, for 1958. North Eastern Division. By H. J. Perrins. Pp. iii+46+4 plates. (London: H.M. Stationery Office, 1959.) 3*s*. 6*d*. net. [174

New Developments in Training: Five Studies in the Efficient Communication of Skills. Edited by Frank A. Heller. (New Development Series, No. 3.) Pp. 80. (London: Polytechnic Management Association, 1959.) 5*s*. [174

Quercus L. By Eustace W. Jones. (Biological Flora of the British Isles, No. 68. Reprinted from the *Journal of Ecology*.) Pp. 169–222. (Oxford: Blackwell Scientific Publications, 1959.) 8*s*. 6*d*. [174

Imperial Cancer Research Fund. Fifty-sixth Annual Report, 1957–1958. Pp. 39. (London: Imperial Cancer Research Fund, 1959.) [174

Anti-Locust Bulletin No. 32: The Colour Patterns of Hoppers of the Desert Locust (*Schistocerca gregaria* Forskål). By Dr. W. J. Stower. Pp. ii+75+17 tables, 24 figures and 5 coloured plates. (London: Anti-Locust Research Centre, 1959.) 45*s*. [174

Ministry of Housing and Local Government. Second Progress Report of the Standing Technical Committee on Synthetic Detergents. Pp. 10. (London: H.M. Stationery Office, 1959.) 9*d*. net. [174

Association of Agriculture. Annual Report for 1958. Pp. 12. (London: Association of Agriculture, 1959.) [174

Ciba (A.R.L.), Limited. Technical Notes No. 196, (April, 1959): Glued Timber Fans and Impellers. Pp. 10. (Duxford: Ciba (A.R.L.), Limited, 1959.) [174

Other Countries

United States National Museum. Bulletin No. 216: Ichneumon-Flies of America North of Mexico. 1: Subfamily Metopiinae. By Henry and Marjorie Townes. Pp. ix+318. (Washington, D.C.: Government Printing Office, 1959.) 1.25 dollars. [174

Science Information News, Vol. 1, No. 1, (February-March, 1959.) (Reporting National and International Developments in Scientific and Technical Information.) Published bi-monthly. Annual subscription: 1.75 dollars. Single copies: 25 cents. (Washington, D.C.: National Science Foundation, 1959. Obtainable from Superintendent of Documents, U.S. Government Printing Office, 1959.) [174

United States Department of Agriculture. Leaflet No. 444: The Narcissus Bulb Fly: How to Prevent Its Damage in Home Gardens. By C. F. Doucette. Pp. 9. (Washington, D.C.: Government Printing Office, 1959.) 5 cents. [174

Records of the Australian Museum. Vol. 24, No. 7: Variation in the Australian Kingfishers (*Aves: Alcedinidae*). By Allen Keast. Pp. 61–72. Vol. 24, No. 8: Variation and Speciation in the Australian Flycatchers (*Aves: Muscicapinae*). By Allen Keast. Pp. 73–108. Vol. 24, No. 9: New Upper Permian Homopters from the Belmont Beds, (Homoptera: Insects). By J. W. Evans. Pp. 109–114. Vol. 24, No. 10: The Permian Gastropods of New South Wales. By H. O. Fletcher. Pp. 115–164+plates 7–21. Vol. 24, No. 11: Liotiidae and Allied Molluscs from the Dampierian Zoogeographical Province. By Charles F. Laseron. Pp. 165–182. Vol. 24, No. 12: A Key to the Australian Families of Acalyptrate Diptera. By David K. McAlpine. Pp. 183–190. (Sydney: Australian Museum, 1957 and 1958.) [174

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National Science Foundation. Scientific Research and Development in Colleges and Universities: Expenditures and Manpower, 1953-54. Pp. iii+173. (Washington, D.C.: Government Printing Office, 1959.) 1 dollar. [174

Annals of the New York Academy of Sciences. Vol. 74, Article 3: Chlorpropamide and Diabetes Mellitus. By Martin G. Goldner and 178 other authors. Pp. 407–1028. (New York: New York Academy of Sciences, 1959.) 5 dollars. [174

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United States Department of the Interior: Geological Survey. Water-Supply Paper 1352: Quality of Surface Waters of the United States, 1954. Parts 7–8: Lower Mississippi River Basin and Western Gulf of Mexico Basins. Prepared under the direction of S. K. Love. Pp. x+499. 1.75 dollars. Water-Supply Paper 1426: Ground-Water Resources of the Hueco Bolson Northeast of El Paso, Texas. By D. B. Knowles and Richard A. Kennedy. Pp. iv+186+11 plates. n.p. Water-Supply Paper 1460-E: Geological and Geophysical Study of the Preglacial Teays Valley in West-Central Ohio. By Stanley E. Norris and H. Cecil Spicer. Pp. iii+199–232+plates 7 and 8. 55 cents. Water-Supply Paper 1477: Annotated Bibliography on Artificial Recharge of Ground Water Through 1954. By David K. Todd. Pp. iii+115. 50 cents. Professional Paper 294-J: Conodonts from the Chappel Limestone of Texas. By Wilbert H. Hass. Pp. iii+365–399+plates 46–50. n.p. (Washington, D.C.: Government Printing Office, 1959.) [174

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New Zealand Forestry Research Notes. No. 14: Combined Taper and Volume Tables for European Larch—New Zealand, 1956. By S. W. Burstall. Pp. 22. (Wellington: Government Printer, 1958.) [284

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Scientifique No. 75: Moisissures du Sol et des Litières de la Région de Yangambi (Congo Belge). Par J. Meyer. Pp. 211+4 planches. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1959.) 190 Belgian francs. [284

Register of Current Scientific Research at South African Universities, 1958. Pp. viii+235. (Pretoria: South African Council for Scientific and Industrial Research, 1958.) [284

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